Aircraft MUNITIONS

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NAVY TRAINING COURSES

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AIRCRAFT MUNITIONS

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PREFACE

This book is written for the enlisted men of Naval aviation. It is one of a series of books designed to give them the background information necessary to perform their aviation duties.

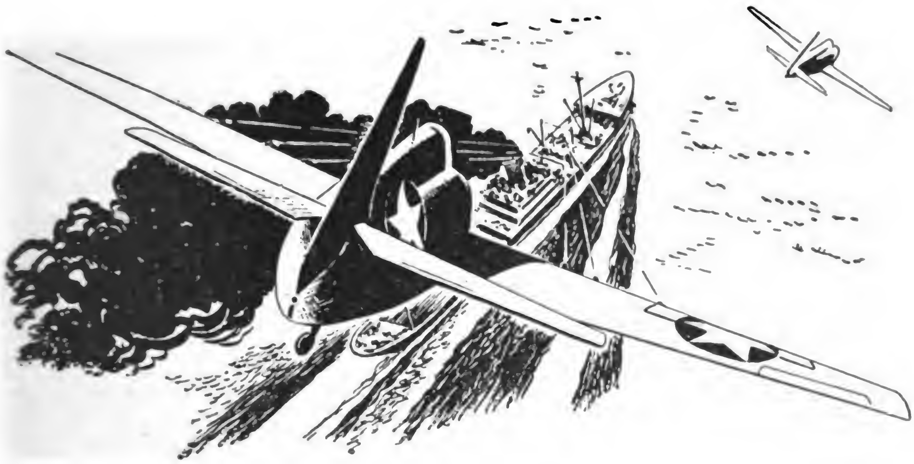
A knowledge of aircraft munitions is of primary importance to Aviation Ordnancemen responsible for general maintenance work. But the subdivisions of Aviation Ordnancemen—that is, Aviation Bombsight Mechanics and Aviation Turret Mechanics—also need an understanding of aircraft munitions. They need to know the relationship of their specialties to the broad subject of ordnance.

Starting with basic information on explosives, this book takes up ammunition for small arms, machine guns and 20 mm aircraft guns. A discussion of bombs and fuzes, torpedoes and rockets follows. Then come mines, pyrotechnics and smoke screen equipment, and destructors.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the Naval Air Technical Training Command and the Training Division of the Bureau of Naval Personnel.

TABLE OF CONTENTS

AIRCRAFT MUNITIONS



CHAPTER I

EXPLOSIVES AND HOW THEY WORK

WHAT IS AN EXPLOSION?

Back when the Fourth of July meant a case of firecrackers in every home, one good way to make a loud noise was to touch off a firecracker under a tin can. The firecracker EXPLODED with a BANG, the tin can soared up in the air and came down to roll about on the pavement with a nice, nerve-shattering racket that sent the nearby members of the older generation off in search of ear muffs and aspirin.

If you remember, a rather small firecracker would blow a rather large can surprisingly high—thereby providing a simple and dramatic illustration of the power developed by an EXPLOSION.

What IS an explosion? What force within the firecracker blows the tin can aloft? What is there about dynamite that enables it to blast great chunks out of mountains, to destroy buildings, and generally mess up the surrounding landscape?

Take the example of the firecracker and the tin can. If you had wanted to, you could have cut the firecracker open and poured its explosive contents out into your hand. You would have found that they consisted of

a granular substance of a definite WEIGHT and VOLUME. A chemist would say that this substance was in SOLID form, since it was not in the form of a liquid or a gas.

Now here's what happens when that explosive substance is inside the firecracker and you touch a match to the fuse.

The heat from the burning fuse ignites the substance —which BURNS with extreme rapidity. In burning, the various materials in the substance combine with OXYGEN and these materials are TRANSFORMED from SOLIDS to GASES.

A gas has WEIGHT and VOLUME, too, but obviously a quantity of gas EQUAL IN WEIGHT to a solid substance would occupy MUCH MORE SPACE, unless it is compressed, than the solid. That is to say, ITS VOLUME WOULD BE MUCH GREATER.

In an explosion, therefore, the original explosive substance—in this case a solid—is rapidly transformed into GASES of EQUAL WEIGHT, but of MANY TIMES GREATER VOLUME than the original substance.

In the firecracker, this chemical transformation takes place inside a paper case—which means that the gases, as they are formed, are CONFINED. Since their volume is so much greater than that of the original solid substance, the gases have to get out of that paper case to EXPAND—so there is a terrific PRESSURE which bursts the case and blows the tin can into the air.

One thing more—the burning action generates great HEAT, which causes an EVEN GREATER EXPANSION of the gases, and this, naturally, results in a FURTHER INCREASE IN PRESSURE.

After the firecracker has exploded, all that remains is a few bits of paper and the dented tin can. The original explosive substance has disappeared, having been transformed into gases which have been dissipated in the atmosphere.

Actually, however, nothing has been lost. The original ATOMS which formed the MOLECULES of the explosive substance have not been destroyed. They are once again going about their business—but now they are a part of a gaseous, rather than a solid, substance.

What's this about ATOMS and MOLECULES? Well, you've probably heard some bright eyes at a party say, "No thanks, I'll just have a glass of H_2O."

"H_2O" is chemical shorthand for what the average person calls "water." In the language of chemistry, it means that a MOLECULE of water is composed of TWO HYDROGEN ATOMS and ONE OXYGEN ATOM.

All matter is composed of atoms, and atoms group themselves together to form molecules. A molecule, then, is a COMBINATION OF ATOMS.

Now here's the point—in an explosion, the atoms break away from one molecule-pattern (comprising the original explosive substance) and regroup themselves into a new molecule-pattern (the gases resulting from the explosion). The atoms themselves are not destroyed—they simply emerge in a new combination.

An explosive substance represents an UNSTABLE CHEMICAL COMBINATION. This means that the atoms are INSECURELY COMBINED into molecules, and that a stimulus in the form of heat, or a shock, will cause them to fly apart and reform into a new and more stable relationship.

There, in a nutshell, is the chemical action that goes by the name, "explosion." A true explosion is always characterized by the formation of gases, the presence of heat, and extremely rapid action.

When you strike a match, you see a chemical action which is closely related to an explosion. As the match burns, gases are formed and heat is generated, but the process is not particularly rapid. Also, the match is not confined when you strike it, and the gases can dis-

sipate themselves in the surrounding atmosphere as quickly as they are generated.

Likewise, most explosive substances, if they are not confined, will not explode. For example, gasoline, when vaporized in the carburetor of your automobile and compressed within the cylinders, is a powerful explosive—powerful enough to drive your car along the road. But if you drop a lighted match into a puddle of gasoline on the ground, it may burn but it will not explode. As it burns, it gives off gases, but since the gases are not confined, there is no power behind them —they merge with the air as rapidly as they are formed.

WHAT IS AN EXPLOSIVE?

So much for an EXPLOSION. Next, you may well ask, what is an EXPLOSIVE?

Well, that's almost like asking, what is an engine? There are electric engines, gasoline engines, diesel engines, powerful engines, engines which aren't so powerful, big engines, little engines, and so on. It's the same with explosives. There are many different kinds.

There is one thing which is common to all explosives however—the presence of NITROGEN. The NITROGEN ATOM is a very unfriendly little guy who combines with other atoms to form molecules only under protest. It is the presence of nitrogen which makes an explosive substance UNSTABLE.

Without trying too hard, you can undoubtedly think of several different kinds of explosive substances. Gasoline vapor and dynamite are two with which almost everyone is familiar.

What you are interested in, however, are the explosives used for MILITARY purposes. What are the characteristics of an ideal military explosive?

All military explosives have certain things in common. In the first place, they must be moved about and stored under various conditions and circumstances, so they must be SAFE in use, easy to HANDLE, and STABLE in STORAGE under varying conditions over a considerable period of time. An unstable explosive will change its chemical composition as it gets older. A stable one stays the same.

Some research chemist might stumble across a new explosive compound powerful enough to blow a ten-ton truck from San Diego to Tokyo—but if it blew up when you so much as looked at it, it wouldn't have much practical military value, would it?

Also, military explosives must have POWER. In addition to being safe, they must pack a heavy wallop. How is the "power" of an explosive measured?

Originally, it was thought that the SENSITIVITY of an explosive was an indication of its power. Sensitive explosives are the kind that go off if you look at them. Insensitive explosives need a powerful stimulus to make them explode. But now it is known that some of the most INSENSITIVE explosives (those that require a strong stimulus to set them off) are among the most powerful ones, too.

Thus, sensitivity is no yardstick. Rather, THE SPEED OF CHEMICAL CHANGE is the true measurement of an explosive's power. The speed of chemical change is reflected in the RATE OF DETONATION. This can be measured when a known quantity of an explosive is exploded under controlled laboratory conditions.

The rates of detonation of the many explosives now in use in the Navy vary from one meter per second to approximately 9,000 meters per second. This means that if a bar of explosive a meter long were detonated at one end, the far end would detonate one second later, in the slowest case, or 1/9,000 second later in the fastest case. Quite a range.

LOW EXPLOSIVES

Explosives fall into two very distinct classes with widely different rates of detonation—low explosives and high explosives.

Low EXPLOSIVES have slow rates of detonation and therefore take quite a while to go off, comparatively speaking. What is more important from a practical point of view, the length of time of the explosion can be controlled. This can be done because a low explosion is merely an extremely rapid BURNING of the explosive. Each grain of explosive burns much like a log of wood in a fireplace.

If you burn a log of wood, you know that the outer surface burns first. The inside cannot burn until the outer portion has burned away and exposed it. In the same way, a grain of low explosive burns from the outside in. The SPEED with which this burning occurs depends on several things. For one thing, the presence of HEAT and PRESSURE greatly accelerates the burning. If a grain of smokeless powder—a typical low explosive—is ignited in the open, it will burn like a piece of celluloid—fairly rapidly but not at all explosively.

But now put the smokeless powder in a closed case, such as the breech of a gun. As soon as the burning starts, it will generate heat and give off gases. Because the gases are CONFINED in the gun, they will start building up pressure. As the heat increases and pressure builds up, the burning of the smokeless powder will proceed faster and faster, generating ever more heat and pressure and still further accelerating the burning. All of this happens in a fraction of a second.

Thus, one way of CONTROLLING the speed of explosion of a low explosive is by controlling the SIZE OF THE CHAMBER in which a certain quantity of explosive is confined.

You have seen that a low explosive burns from the

surface of each grain inward. The more SURFACE exposed, the faster the burning. Now if an ounce of explosive is divided into 50 separate grains, the total surface exposed will be less than if it is divided into, say, 100 grains. The amount of exposed surface can also be increased by cutting HOLES through the grains. Then the wall of each hole provides additional surface.

By both these means—by adjusting the size of the confining SPACE, and by changing the size and shape of the powder GRAINS—the rate of explosion of low explosive is controlled in practical ballistics.

Are you wondering why it makes any difference whether powder explodes in one thousandth of a second or in two thousandths?

Well, think what goes on in a gun. What you want is to push the projectile out of the barrel with as much velocity as possible. One sudden wallop against the projectile is not the way to do that. What you want is a blow with follow-through. You want the explosion to be pushing against the projectile all the time it is in the barrel. And you want this pushing to be finished when the projectile leaves the barrel, because any further explosion is just wasted. That's why you have to time the explosion. You want it to last just as long as the projectile is in the barrel and no longer. That way, you'll get the most work out of the explosion.

HIGH EXPLOSIVES

When you want to do damage with an explosion instead of doing work, the situation is different. Here you want a quick, shattering blow rather than a sustained push. For such uses—as in the filling of bombs, shells, and torpedoes—HIGH EXPLOSIVES are used.

A high explosive has a chemical reaction quite different from that of a low explosive. It does not just burn rapidly. It DETONATES. That is, the entire mass

of the explosive—inside as well as outside—is suddenly, almost instantaneously, converted into a gas. The speed with which this happens is a basic property of the explosive itself and cannot be controlled. TNT is an explosive of this type.

It is usually rather hard to start the detonation. It requires a considerable amount of heat and pressure. The easiest way to provide this heat and pressure is by ANOTHER EXPLOSION.

Sometimes, a low explosive such as black powder can be set off, and this explosion will generate the required heat and pressure. Sometimes use is made of certain peculiar explosives which are both low explosives and high explosives. The commonest of these are MERCURY FULMINATE and LEAD AZIDE. These materials can easily be made to begin a low explosion. As they explode, they generate heat and pressure, and they convert their own explosion into a high order detonation.

If a high explosive is set afire or subjected to great shock, but there is not enough heat and pressure to detonate it, it may burn harmlessly or it may produce a weak low explosion. When a high explosive goes off with a weak low explosion, it is said to detonate LOW ORDER.

BLACK POWDER

Curiously enough, one explosive served all military uses until the time of our Spanish American War. BLACK POWDER is its name.

Many, many years ago, the Chinese discovered that a mixture of saltpeter, sulphur, and charcoal, when confined and touched off with a fuse, would explode with a loud noise and lots of smoke. For a long time the principal use for this volatile black substance was to scare away evil spirits. But in the year 1346 some

smart feudal warrior employed it as a propellant to shoot missiles out of wooden cannons in the historic battle of Crecy. It was not until 500 years later that any basically new explosives came into general military use.

Meanwhile, many experiments were made in firearms. Man was continually striving for greater accuracy and power in his explosive weapons, and cannon were redesigned constantly so that they would take heavier and heavier charges of black powder.

No one knew very much about how or why black powder worked. All that the military men of the time knew was that the more black powder you could pack into a cannon, the more punch the explosion would carry. Naturally, as the weight of the charge was increased, the walls of the firing chamber in the cannon had to be thickened, because no one knew anything about controlling the speed of explosion of black powder, and a heavy charge would burst the barrel of any but a very thick-walled gun.

Finally, cannon became too heavy and unwieldy to move. During the latter part of the 18th century, short, squat and stubby models weighing a couple of tons were developed. The weight and unwieldiness of cannon had reached their highest practical limits, and the next step forward had to be that of improving the explosive.

It was not until 1860 that General Rodman of the U. S. Army discovered the principle of the progressive combustion of black powder. He suggested that black powder be prepared in grains of a certain shape, and that each grain be perforated with a hole so that it would burn evenly both from the outside in and from the inside out. This discovery provided an important step forward. It made black powder a vastly improved propellant. Since it burned more evenly, it produced a

more steady and continuous force of pressure behind the projectile.

BLACK POWDER SUPPLANTED

Meanwhile, chemistry had begun to come into its own as a science. Among other things, the pioneer chemists investigated the WHY behind black powder's powerful source of chemical energy. As these early chemists experimented, they learned that many materials, such as cotton, starch, sugar, and glycerine, when combined with NITROGEN in the form of NITRIC ACID, had great explosive possibilities. Following these discoveries, long strides were made in the development and refinement of new explosives. Nitroglycerine, dynamite and ammonia gelatine, guncotton, pyrocotton, and smokeless powder were all developed in the 19th century. And all of them, with some modifications, are still in use. During this period of development, many disastrous explosions occurred, because the nitrating process, when the proper precautions are not taken, is about as easy to control as a bull in a china shop.

Today, of course, there are many different military explosives in use. In the field of Aviation Ordnance alone, there are quite a number.

Black powder has been almost entirely supplanted by SMOKELESS POWDER as a propellant. Some explosives are used to "explode" other explosives, and different explosives are mixed in various combinations to provide a new explosive tailor-made for a certain task.

But the basic action of every explosive is the same—a RAPID chemical transformation accompanied by HEAT which produces GASES under great PRESSURE.

And why is it essential that you LEARN AND REMEM-

BER all that you possibly can about the various explosives used in Aviation Ordnance?

Very simple—so that the explosives you work with will save their power to use on the enemy and will not take it out on YOU.

Different explosives have what you might call different personalities. They behave differently, and they react in different ways to the same treatment.

Think of them as being people—fellow workers in winning the war, so to speak. You'll find that they aren't temperamental or touchy, that they're good guys to have around AS LONG AS YOU TREAT THEM RIGHT.

There are only two things they resent—IMPROPER CARE and BAD HANDLING. Learn all you can about their habits, and their likes and dislikes. Apply this knowledge CONSTANTLY as you work with them from day to day and you'll have no trouble.

But—just kick them around, and you'll probably fly all to pieces before you even have a chance to apologize.

In Aviation Ordnance, explosives are used, not only in what you usually think of as "ammunition," but also in bombs, fuzes, torpedoes, pyrotechnics, mines, aircraft catapults, and so on—which brings you to your $64 question.

What explosives ARE used in Aviation Ordnance and what are the principal characteristics and specific uses of each?

USES OF LOW EXPLOSIVES

BLACK POWDER, as you know, was the only military explosive in general use until late in the 19th century. Originally, black powder was made by mixing saltpeter (sodium nitrate), sulfur, and charcoal together in equal proportions, but the modern blend is 75 percent saltpeter, 10 percent sulfur, 15 percent charcoal.

Today the most important single use of black pow-

der is as an ignition charge for smokeless powder. Its high inflammability makes it ideally suited for this purpose. Black powder is also used as the propelling charge in Y-guns used for launching depth charges, and sometimes for torpedo impulses. It is frequently employed as the charge for signals and salutes.

SMOKELESS POWDER has almost completely supplanted black powder as a propellant. Black powder, after exploding, leaves a large amount of residue which fouls the gun bore, and in large caliber guns it gives off a great cloud of black smoke which obscures the sight of the target. Also, it is very HYGROSCOPIC—which means it is likely to absorb moisture, thus reducing its explosive power. And it burns at such a high temperature that it tends to erode the walls of the firing chamber of the gun. Smokeless powder, to a large degree, overcomes these disadvantages.

Smokeless powder is manufactured by treating cellulose with nitric and sulphuric acids. Cellulose is a woody substance which is found in the cells of all types of plants. Raw cotton contains about 90 percent of pure cellulose, so cotton is the source of cellulose employed in the manufacture of smokeless powder.

Recent developments have resulted in several new classifications of smokeless powder, notably "smokeless powder non-hygroscopic"—which does not absorb water readily, and "smokeless powder flashless non-hygroscopic," in which certain chemicals have been added to reduce the flash of explosion.

Smokeless powder, when stored in POWDER BAGS on board ship for use in large caliber guns, must be tested frequently for deterioration. In Aviation Ordnance, however, you will have little or no occasion to handle smokeless powder in bulk. It is the propellant charge in small arms ammunition cartridges—calibers .30, .45, and .50—and in this form it is always packed within the cartridge case.

An early form of smokeless powder which recently came back into use in connection with rockets is BALLISTITE.

USES OF HIGH EXPLOSIVES

The principal military use for high explosives is as a BURSTER CHARGE in projectiles, mines, bombs, torpedoes, and so forth. There are many substances which qualify as high explosives, but relatively few of them have military value, since a high explosive for military use must fulfill certain definite conditions. Specifically, it must be sufficiently insensitive to withstand the shock of gunfire and the shock of handling and transportation.

Ideally, it should not explode if bullets are shot through it or if a projectile loaded with it strikes armor. SOME COMPROMISES HAVE TO BE MADE ON THIS POINT, HOWEVER. For instance, TORPEX, a valuable explosive for underwater ammunition such as torpedoes and depth bombs, is not bulletsafe—it will sometimes go off when a bullet hits it. And TNT, the most common military high explosive, is not bulletsafe under some rare conditions, and it is definitely too sensitive to withstand the impact of a high velocity projectile on heavy armor.

In addition, a good military explosive should be able to withstand adverse storage conditions due to heat, moisture, etc., should be easy to handle and use—and should lend itself to manufacture in quantity.

Naturally, not every military high explosive can score 100 percent on all of these counts, but the following high explosives now in use in the Navy were selected because they best fulfilled these general specifications—

TNT stands for TRINITROTOLUOL. Toluol is derived from coal tar, and TNT is made by treating toluol with

a mixture of nitric and sulphuric acid—not once (mononitrotoluol), not twice (dinitrotoluol), but THREE TIMES (trinitrotoluol).

After the nitration process is complete, the TNT is in a molten state, and can be CAST by pouring it as a liquid into a container and letting it solidify.

Grade *B* TNT, which has a certain amount of impurities present, is likely to give off an EXUDATE (a dark brown, oily liquid), particularly when stored under high temperatures. Grade *B* is now rarely used. When it soaks into any combustible material such as wooden flooring or cotton waste, exudate forms a low explosive which is highly inflammable.

TNT is quite insensitive to shocks, friction, or pressure. When it is ignited, if it is not confined, it burns slowly without exploding, producing a dense black smoke. It ignites at 300° C.

If a serious fire occurs near or among TNT charges, however, the TNT will probably explode. For this reason, all shipboard magazines containing TNT charges should be fully equipped with flooding and sprinkling systems.

In what type of ordance items is TNT used in Aviation Ordnance? Well, you will probably have more to do with TNT than any other single high explosive. It is used in cast form as the main charge in torpedo warheads, mines, depth charges, and bombs.

Cast TNT is quite difficult to detonate, so TNT which has been granulated and then pressed is sometimes used as a BOOSTER charge in mines, bombs, etc., to detonate the MAIN CHARGE.

Also, TNT, granulated and compressed into blocks, is used for demolition charges.

Until recently, AMATOL was used widely in bombs as a substitute for TNT. The three steps or nitrations required to manufacture TNT make that substance so expensive that it has practically no peacetime com-

mercial use. This also makes it hard to expand the manufacture of TNT quickly in war time. Ammonium nitrate is an explosive with about the same power as TNT, and ammonium nitrate can be produced in a single nitration process.

However, ammonium nitrate is so insensitive that it is almost impossible to detonate it. But if ammonium nitrate is mixed with TNT, the explosion of the TNT will be sufficiently powerful to detonate the ammonium nitrate. Thus the mixture—which is known as amatol—becomes a usable military explosive. The proportion most commonly used is fifty-fifty.

Amatol behaves in almost exactly the same way as TNT, and costs less to manufacture. It is therefore used in most bombs manufactured in this country. Its one serious disadvantage is that it is hygroscopic. (It absorbs and retains moisture.) To prevent bombs loaded with it from absorbing moisture, pure TNT is always poured around any openings in the bomb that might possibly leak. TNT is not hygroscopic and so acts as a seal for the amatol.

EXPLOSIVE "D" is another name for AMMONIUM PICRATE. This explosive was first patented in 1888, and for a number of years it was the secret high explosive of the United States.

It is inferior to TNT in explosive force, but its compensating feature is that it is LESS SENSITIVE THAN TNT, and is thus better adapted for use as the burster charge in armor-piercing projectiles and bombs.

In appearance, Explosive "D" is a crystalline powder varying in color from orange to deep red, depending upon the method of manufacture.

Ordinary variations in temperature have no effect on Explosive "D," and it is highly insensitive to shock, friction or pressure. It must be kept dry, however, for in a damp atmosphere it will absorb up to 4 percent

moisture, thereby losing power and becoming more difficult to detonate.

As with TNT, when Explosive "D" is ignited and is not confined, it burns slowly and with a dense black smoke. If it is confined and heated to its ignition temperature of 300° C. it will explode.

TORPEX is a new explosive just now coming into use in depth bombs, torpedoes, and other underwater ordnance. It is considerably more powerful than TNT. A hundred pounds of torpex will do the same underwater damage as about 150 pounds of TNT. Since torpex is a little heavier than TNT, a cubic foot of torpex will do as much damage as 1.7 cubic feet of TNT. Like TNT, torpex is cast.

DETONATORS AND BOOSTERS

So far, you have read about low explosives—or propellants—and high explosives—or burster charges. You also know that there are only two main classes of explosives, low explosives and high explosives. You might ask, therefore, "What is this new classification called 'detonators and boosters?' "

The answer is that detonator and booster explosives still are classified as low explosives or high explosives. They are presented here as a separate class because their function is to IGNITE a propellant charge, or to DETONATE a high explosive burster charge.

BLACK POWDER, with which you are already familiar, is used in large caliber guns to ignite the main propellant charge of smokeless powder.

MERCURY FULMINATE, sometimes called fulminate of mercury, has been used in PERCUSSION CAPS for many years. It is extremely sensitive—so sensitive, in fact, that accidents often occur in its manufacture.

In Aviation Ordnance, the only use of mercury fulminate is in the percussion caps of small arms am-

munition, and the primers and detonators in certain bomb fuses.

The FIRING PIN of a gun or a fuze detonates the mercury fulminate charge. This, in turn, detonates the next charge in the train of explosives.

TETRYL's proper chemical name is a real monicker—trinitrophenylmethylnitramine. Just call it "tetryl" for short.

Tetryl is about 18 percent more powerful than TNT, but it is too easily detonated to be used in large quantities as a main charge. It is used almost exclusively as a BOOSTER charge to detonate a burster charge of TNT, Explosive "D", or some other high explosive.

The same precautions for handling TNT apply to tetryl.

CHAPTER 2

GUN AMMUNITION

CLASSIFICATION OF AMMUNITION

"Pass the ammunition" is a phrase that is as old as warfare itself. To the supply officer in the medieval army it meant, "Hustle some more arrows to the boys out front." To the pioneer women of the American frontier it meant that their menfolk were calling for more powder and shot.

And so it goes. The exact meaning of the word "ammunition" is modified with the development of each new weapon of war.

Most people think of the word as applying only to the charges fired in guns. But its correct meaning is much broader in scope. In the Navy, AMMUNITION refers to "all component parts and substances which, when assembled, constitute A CHARGE FOR ANY TYPE OF WEAPON."

Thus, ammunition includes torpedo warheads, mines, bombs, depth charges, demolition charges,

fuzes, detonators, pyrotechnic materials, rockets, explosives and so on.

All ammunition is classed as either SERVICE ammunition, or TARGET ammunition. Service ammunition is for use in BATTLE, while target ammunition is for use in TRAINING.

This chapter deals with the ammunition used in SMALL ARMS, MACHINE GUNS, and AIRCRAFT CANNON—the GUN department in Aviation Ordnance.

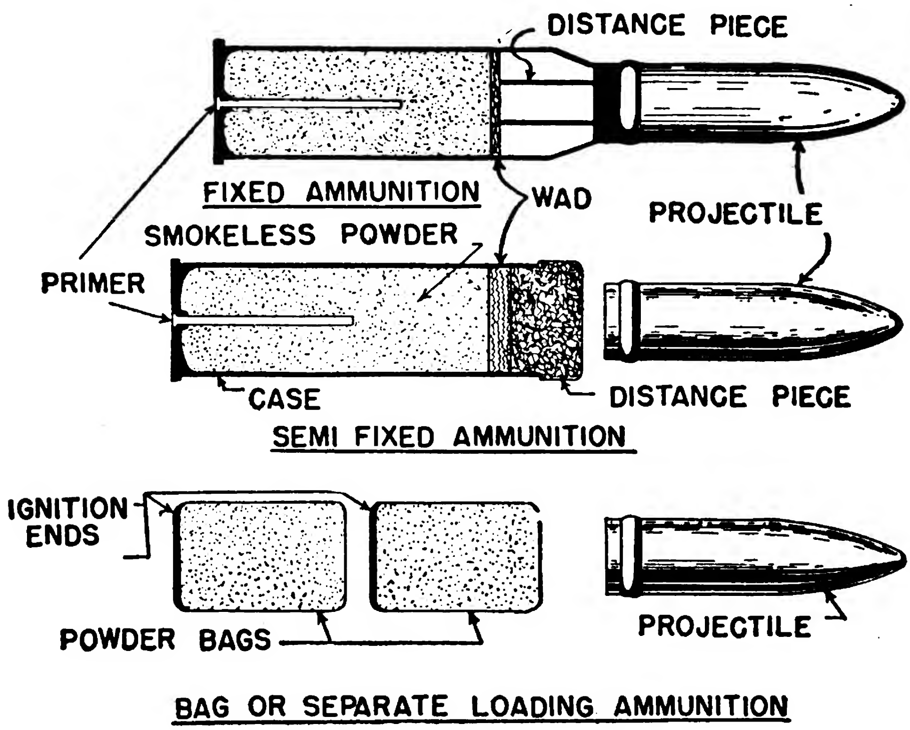


Figure 1.—Separate loading, semi-fixed and fixed ammunition.

As a matter of background, however, here's a quick look at the three major classifications of ammunition used in ALL types of guns in the Navy. First, there is SEPARATE LOADING AMMUNITION. All 16-in. guns and some of the smaller guns in the Navy use this type. With separate loading ammunition the PRIMER, PROPELLING CHARGE, and PROJECTILE are loaded into the gun separately in two or more operations.

Second, there is SEMI-FIXED AMMUNITION. In this type, the PRIMER, and the PROPELLING CHARGE are fixed firmly in a CARTRIDGE CASE, while the PROJECTILE is separate. Two operations are required to load semi-fixed ammunition. Semi-fixed ammunition is used in modern 5-in. and 6-in. guns.

Third, there is FIXED AMMUNITION. This type has the PRIMER, PROPELLING CHARGE, and PROJECTILE all contained in a CARTRIDGE CASE. Fixed ammunition is loaded in one operation.

Figure 1, illustrates each of these three types.

The ammunition used in small arms, machine guns, and aircraft cannon is all FIXED AMMUNITION. A single shot is called a ROUND. So if you are ordered to "fire 30 rounds," that means you are to fire 30 shots.

A round is also called a CARTRIDGE. A cartridge, as you know, contains all of the components necessary to fire the weapon ONCE. A cartridge is made up of the cartridge case, the primer, the propelling charge, and the projectile, or bullet.

The CALIBER of a cartridge refers to the DIAMETER OF THE BORE of the gun in which the cartridge is to be used. Caliber is generally measured in INCHES, or parts of an inch, as, for example, Caliber .50, means .50 in., or a half inch.

Often however, caliber is measured in MILLIMETERS, as 20 mm or 37 mm—a millimeter being .039 inches. Guns whose caliber is measured in millimeters are usually adapted from a foreign design.

Also, when you speak of the GAGE of a shotgun, gage refers to the number of LEAD BALLS, OF THE SAME DIAMETER AS THE BORE, REQUIRED TO WEIGH ONE POUND.

Basically, the construction of a cartridge is the same, whether it is to be fired in a revolver, a machine gun, or an aerial cannon. Since the 20 mm cartridge differs somewhat from small arms and machine gun cart-

ridges, however, it will be treated separately at the end of this chapter.

Figure 2, shows cross sectional views of three cartridges, caliber .45, caliber .30, and caliber .50.

When you place a cartridge in the firing chamber of

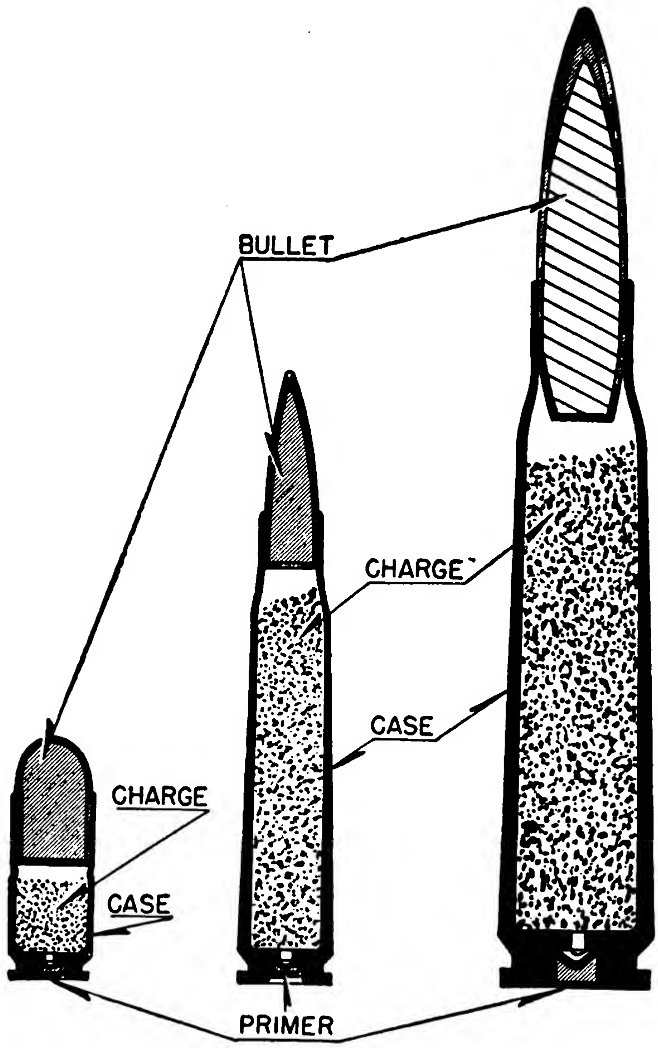


Figure 2.—Cross section of typical cartridges. Left to right—Caliber .45, .30, and .50.

a gun and pull the trigger, the firing pin strikes the PRIMER cup, compressing the fulminate of mercury charge, and exploding it by PERCUSSION. The explosion ignites the propelling charge of smokeless powder,

which explodes—driving the bullet from the gun. There, in brief, is what happens when you "fire" a cartridge.

PARTS OF A CARTRIDGE

Suppose you examine each of the component parts of a cartridge in detail. First, the CASE.

As you see in figure 2, the cartridge case holds everything together, so to speak. The primer, propelling charge and bullet are fixed within the case to form one weatherproof unit. When the cartridge is fired, the case EXPANDS against the wall of the firing chamber and prevents the expanding gases from escaping to the

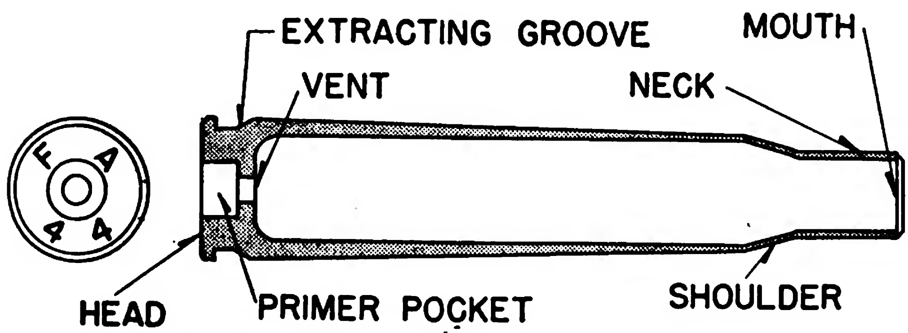


Figure 3.—Cross section of case for caliber .50 cartridge.

rear. In other words, the case forms a tight SEAL which insures that the explosive force of the propelling charge will be applied to the bullet and will not be partially dissipated by leaking out the gun breech.

The CASE is usually made of brass. First, a circular disk is punched from a flat strip of special brass. This disk is punched into the form of a cup, and after several drawing and machining operations, the case is finished. Look at figure 3 and note the names of the various parts of the case.

The head of the case contains the primer pocket, the vent hole, and the extracting groove. The primer fits into the primer pocket, the vent hole permits the flame

from the primer to ignite the main charge, and the extracting groove provides a grip for the extractor mechanism of automatic weapons to withdraw the case from the chamber.

On the head of each case are stamped the initials of the manufacturer and the year of manufacture. In figure 3, "F.A.-44" stands for "Frankfort Arsenal—1944."

Next, the PRIMER.

As you see in figure 4, the primer is comprised of three principal parts, a CUP, a CHARGE, and an ANVIL.

The cup is made either of cartridge brass or gilding

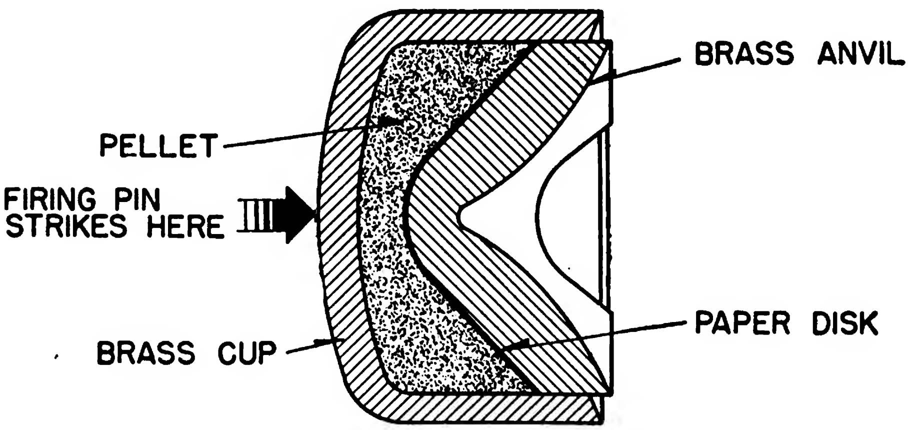


Figure 4.—Cross section of primer for a caliber .50 cartridge.

metal, and the anvil is made of brass. The priming charge (usually fulminate of mercury) is loaded into the cup and is held in place by the paper disk, with the brass anvil being inserted last.

The cup must be soft enough to be indented easily by the firing pin of the gun, yet it must not puncture. Also it must be able to withstand the blowback pressure of the gases when the propellant charge explodes.

The cup of the caliber .45 primer is made of gilding metal because the lighter blow delivered by the firing pin of a pistol or revolver necessitates the use of a material which is softer than brass.

Third, the PROPELLING CHARGE.

As you know, the standard propellant used in cartridges is smokeless powder. The weight of the charge may vary between one lot of powder and another. One lot may have slightly more or less explosive force than another—therefore, more or less powder is required to maintain standard bullet velocity.

Smokeless powder for small arms ammunition is usually glazed with graphite (the graphite facilitates

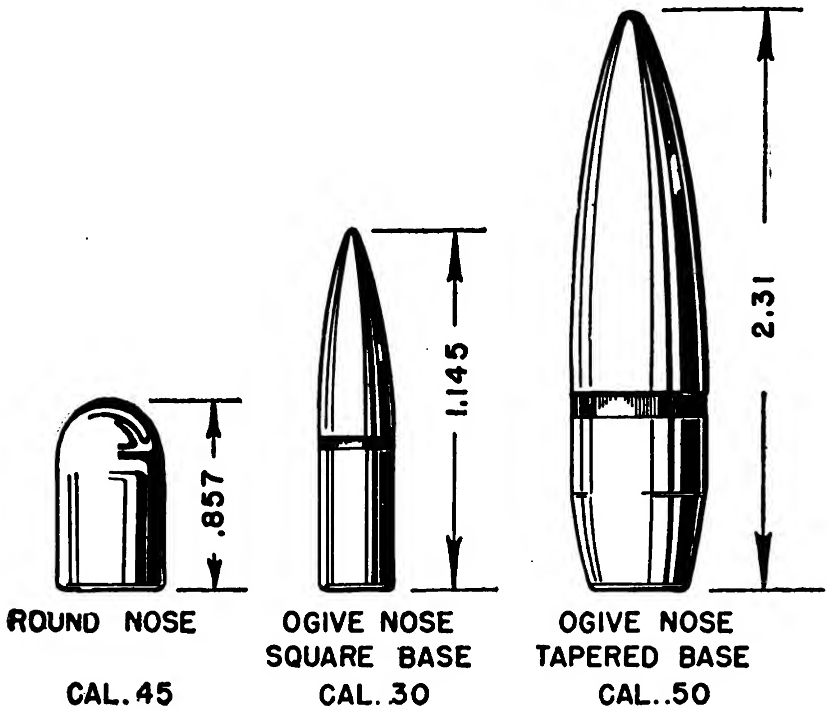


Figure 5.—Representative bullet shapes.

the machine loading process), and it is in the form of short cylindrical grains with one perforation in each grain.

Fourth, the BULLET.

Figure 5 illustrates three typical bullet shapes.

Notice that both the caliber .30 and caliber .50 bullets have a groove known as a cannelure cut into the bullet jacket into which the mouth of the base is

crimped when the cartridge is assembled. The caliber .45 bullet has no cannelure. The cannelure is pressed into its cartridge case.

So much for the various bullet shapes, and now for the different TYPES of bullets.

TYPES OF BULLETS

There are four principal types of bullets. BALL, for use against personnel and light materiel targets. TRACER, for the observation of bullet trajectory and fire control. ARMOR PIERCING, for use against targets mounting armor plate. INCENDIARY, for igniting inflammable targets. The new ARMOR PIERCING INCENDIARY is a combination of the last two.

Figure 6 illustrates the various types of bullets for caliber .22, caliber .45, and caliber .30 weapons.

As you can see, the caliber .22 and the caliber .45 bullets are ball-type projectiles. The caliber .22 is simply a lead-antimony alloy slug, and the caliber .45 bullet is the same composition, except that it has a jacket of gilding metal.

The ball-type caliber .30 and caliber .50 bullets differ in the material used in the core—the caliber .30 has a lead-antimony core whereas the caliber .50 has a lead-antimony point filler and a steel core.

Tracer bullets carry a compressed pyrotechnic mixture which is ignited by the propelling charge in the cartridge case. This mixture burns with a constant intensity and the gunner can easily follow the course of the bullet with his eye to check the accuracy of his aim. A new DELAYED TRACE bullet has a tracer which starts to burn 200 yards from the gun.

The average trace will burn for approximately 600 yards, and it may be either white or colored. The jacket of a tracer bullet is somewhat thicker than that of a ball bullet, and its point is counterbalanced with a

lead alloy so that it will follow the same trajectory as a ball bullet of the same caliber. Thus a tracer bullet will travel just as far and hit just as hard as a ball bullet.

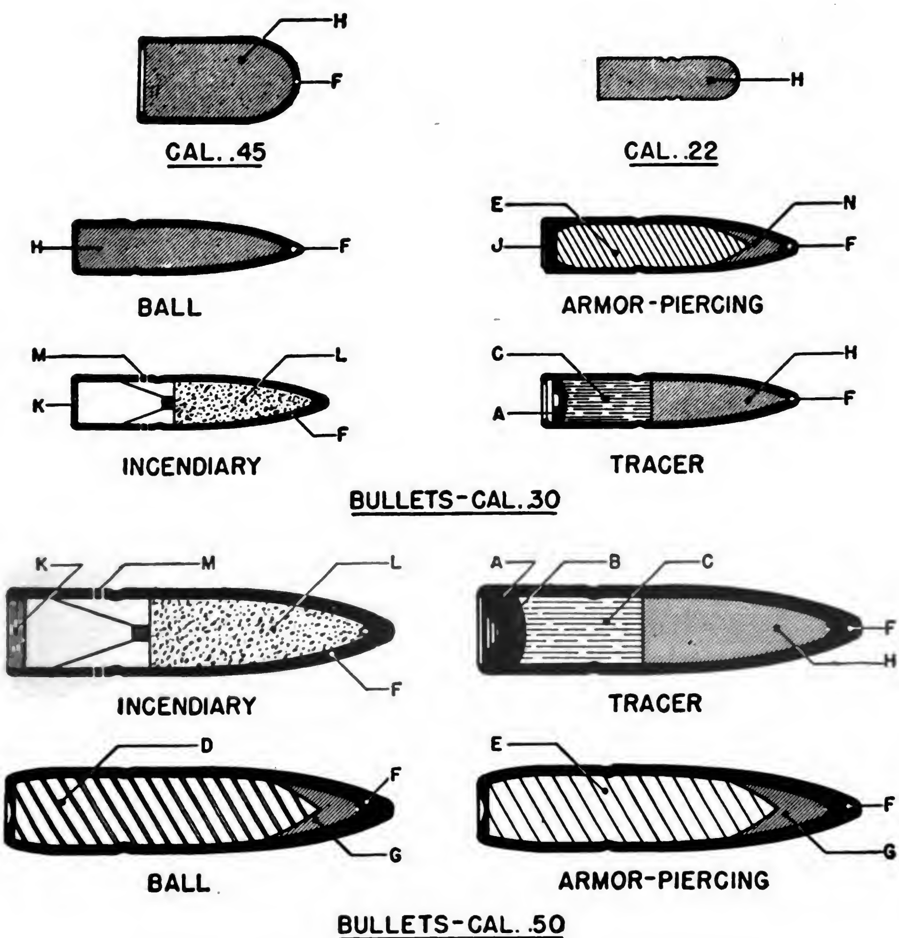


Figure 6.—Cross section of principal types of bullets.

A. Igniter composition—B. Sub-igniter composition—C. Tracer composition—D. Core-steel—E. Core-tungsten chrome steel—F. Jacket-gilding metal—G. Point filler-lead with antimony—H. Slug-lead with antimony—J. Base filler-gilding metal—K. Solder—L. Phosphorus—M. Low fusible alloy—N. Point filler-lead "T" shot.

The tracer bullet is not tapered, having a flat base with an exit orifice for the tracer flame.

Armor piercing bullets have a core of tungsten-chrome steel, shaped and treated to give maximum

penetration. A lead filler in the point helps preserve balance in flight and reduces the bullet's tendency to ricochet on an oblique impact.

Outwardly, the incendiary bullet closely resembles the ball-type bullet, except that its nose is flattened slightly. It has a gilding metal jacket.

Look at the caliber .30 and caliber .50 incendiary bullets illustrated in figure 6. Notice that there are two plugs placed near the base of the bullets. These plugs are made of an alloy metal with a low melting point. As the bullets pass through the gun barrel, friction melts the plugs, leaving two holes in the sides of the bullets. When the bullets hit the air, oxygen enters these holes and ignites the yellow phosphorus incendiary composition. As the bullets travel through the air they produce a one-inch smoke trace by day, and at night a distinct yellowish trace over a range of approximately 300 feet.

Since the incendiary bullet loses weight in flight as the incendiary composition burns, its trajectory varies somewhat from that of the ball-type bullet. Gasoline tanks, balloons, and ammunition dumps are highly vulnerable targets for incendiary bullets.

MISCELLANEOUS AMMUNITION

CALIBER .22 LONG RIFLE is used in pistols, rifles and machine guns for practice and training. Caliber .22 ammunition is the RIM FIRE type, which means that the priming composition is spun into a circular recess inside the rim instead of being contained in a primer cup seated in the center of the case head. A blow from the firing pin at any position on the rim will fire the cartridge.

CARBINE, CALIBER .30 M1 is easily distinguished from other types of caliber .30 by its shape. The case is slightly tapered for its entire length, and the bullet

has a round nose, as compared with the sharp pointed bullets used in other service rifles.

SHOTGUN SHELLS, 12 GAGE, are used in sporting and riot type shotguns for guard duty, trap and skeet shooting in gunnery training, hunting, and sometimes in actual combat.

A shell consists of a case, a primer, several wads, a propelling charge, and a load of lead shot in place of a bullet.

The case has a brass head and a waterproof paper body. In shells used for guard or combat purposes, the head extends 1 inch along the case—in fact, the entire case of some shells is made of brass.

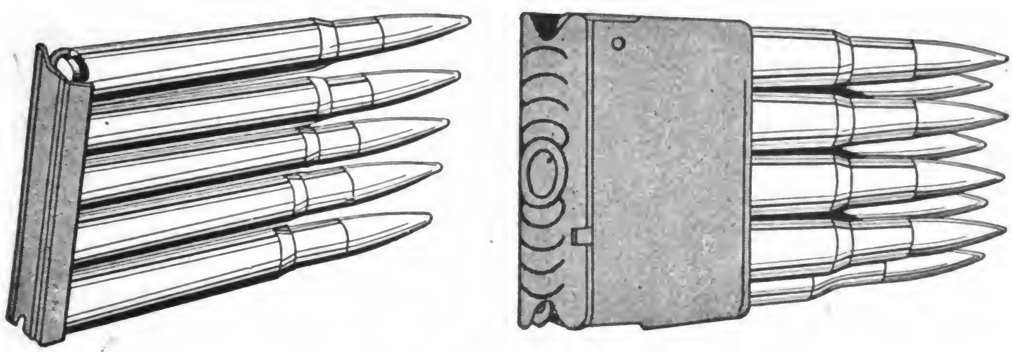


Figure 7.—Cartridge clips.

The head of sporting shells extends ½ inch along the case.

The shot load is weighed in ounces, and the size of the shot determines the use of the shell. Guard or combat shells are loaded with size No. "00" shot—called buckshot, or riot shot. The most frequently used size is No. "7½" shot. It is used for skeet shooting only, as it has little value for hunting.

CLIPS AND LINKS

Caliber .30 ammunition, when used in service rifles, is assembled into either 5- or 8-round CLIPS. Caliber

.45 ammunition can also be assembled into clips when it is to be used in a revolver.

Figure 7 illustrates the 5 and 8 round clips for caliber .30 cartridges.

The caliber .30 5-round clip simply consists of a brass body and brass spring. You can see from figure 7 how the cartridges are held within the clip by flanges fitting into the grooves of the outside cartridges.

The 8-round clip is a steel case, whose sides are inclined sufficiently to clamp the cartridges firmly into place in two staggered rows.

For use in aircraft machine guns, caliber .30 and .50 ammunition must be assembled in metallic LINK BELTS.

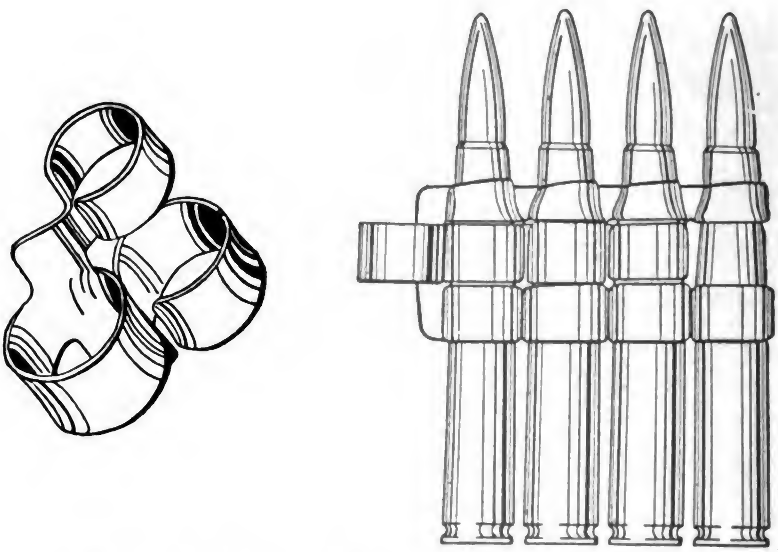


Figure 8.—Section of link belt and individual link.

Figure 8 shows a single link and four cartridges assembled into a belt. Notice that each link unit has three loops—the two thinner loops fit about one cartridge, and the single thick loop fits about another cartridge. When assembled in a link belt, each of the cartridges in the belt is held by the two thin loops of one link and the single thick loop of another link.

The caliber .30 link belt must be able to withstand

an extraction pull of 5—10 lb., and the caliber .50 belt an extraction pull of 10—25 lb.

When ammunition is assembled into metallic links it forms a flexible belt which can be made into any length. As each round is fired and the cartridge is extracted from the belt, one link falls free and is ejected from the gun into a chute which drops it clear of the airplane. All belts must be free from kinks, tight hinge loops, or twisted links. Cartridge heads must be in proper alinement, as any misalinement may cause a stoppage of the gun.

Never oil the links to make the belt more flexible, for this will cause the feed pawls of the gun to gum or slip.

Before you load the ammunition into the airplane, be sure to check the ammunition boxes and feed chutes to see that they are properly alined with the gun. Also, check the ammunition counter for freedom of movement so that the belt won't bind when moving from the ammunition box into the feedway of the gun.

Make certain that there are no obstructions in the ejection and link chutes that might cause the ejected cases and links to jam up and thus cause a stoppage of the gun.

When you load an ammunition belt into a LEFT-HAND FEED gun, the DOUBLE LINK IS TO THE RIGHT. Conversely, when you load a RIGHT-HAND FEED GUN, the double link is to the LEFT.

You can, of course, assemble ammunition into belts by hand, but this is a lengthy and laborious process. Consequently, link belting machines have been devised to perform this operation at high speed. There are two types of machines—the hand operated and the power driven—for both caliber .30 and caliber .50 ammunition.

Figure 9 shows the hand operated machine. The links and the cartridges are placed in the grooves as

shown in the illustration, and the handle is moved forward driving an anvil which pushes the cartridges through the links to the correct depth.

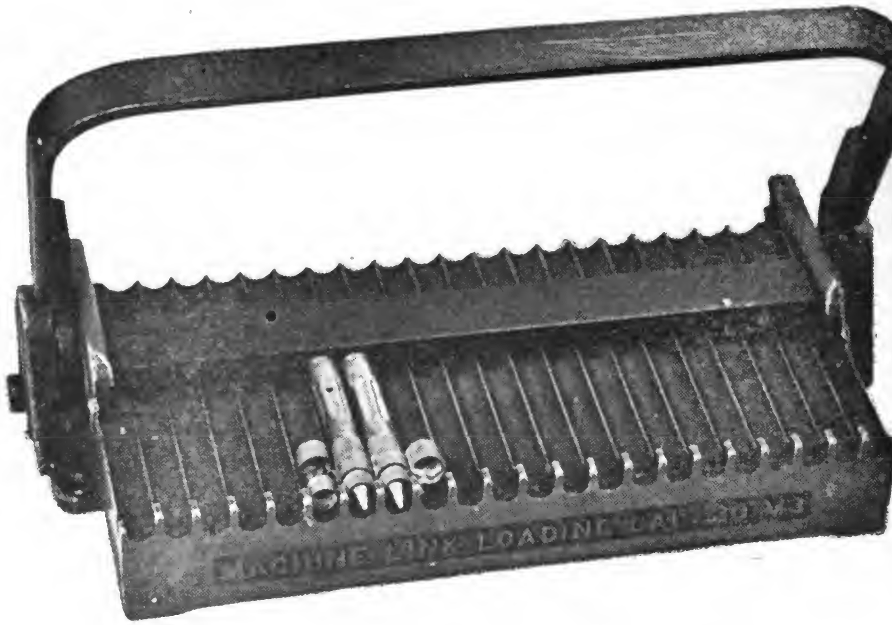


Figure 9.—Hand operated link belting machine.

Power driven machines make it possible for you to belt ammunition with greater speed and accuracy than with the hand operated machines. Power driven machines are made in both PORTABLE and DEPOT models.

Figure 10 shows a power driven machine. The portable model is designed for use by squadrons, and it is available for both caliber .30 and caliber .50 ammunition. This machine will belt 115 rounds per minute, is simple in design, and requires little maintenance. It weighs 114 pounds. In case there is no electric power available, or in the event of a power failure, it can be driven by a hand crank.

De-linking attachments can be fitted to the machine, also, so that it will unbelt, as well as belt, the ammunition.

The caliber .30 machine is designated Mk 1, and the caliber .50 machine is the Mk 3.

The Mk 2 belting machine is for caliber .50 ammunition only. It is designed for use aboard aircraft carriers and at shore stations. Its capacity is approximately 30,000 rounds per hour or 500 rounds per minute, and it incorporates a selective system which permits it to load the four types of ammunition—ball, armor piercing, tracer, and incendiary— in one belt in any desired ratio.

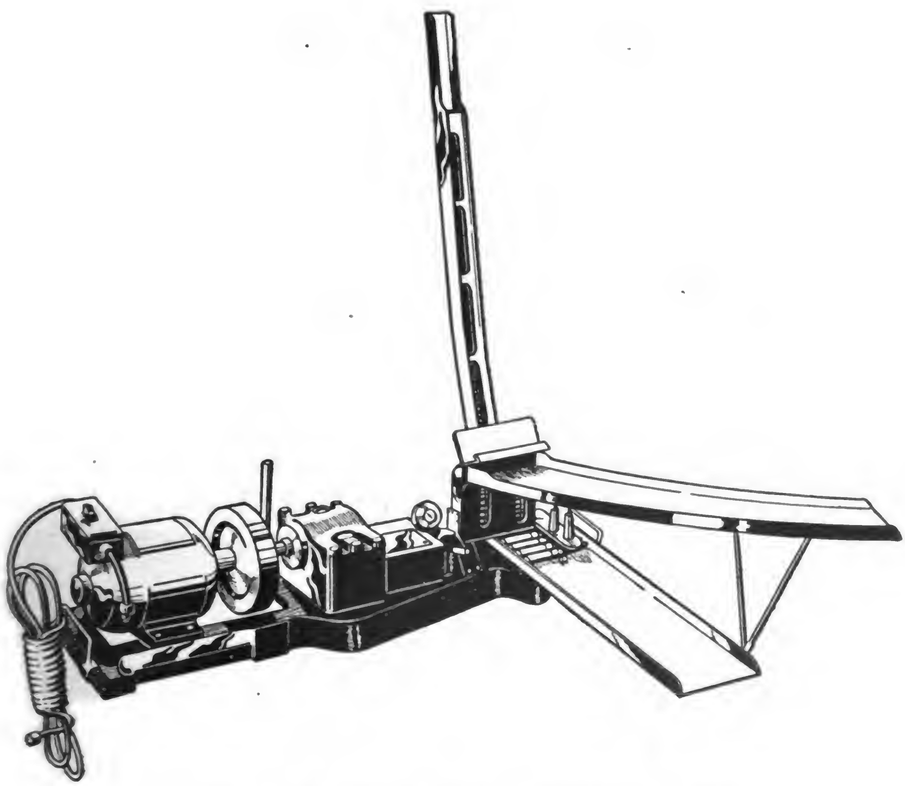


Figure 10.—Power driven link belting machine.

You will find that a power driven belting machine, running at top speed, will require a sizable crew to man it properly, and everyone must be on the constant lookout to avoid jams, stoppages, skips, and so forth.

Unless you are thoroughly familiar with the operation of these machines, you should not attempt any

repairs or adjustments. You should, however, check and service them regularly in accordance with the procedure outlined in the handbook issued with each machine.

GRADING

Rifles, ground machine guns, and aircraft machine guns, even those of the same caliber, have different ammunition requirements.

For example, the EXTRACTION EFFORT required for service rifle ammunition cannot exceed 15 pounds. This is essential for uniform and reliable action in a manually operated weapon. But in aircraft and ground machine guns, it is not so important.

On the other hand, synchronized and remote-controlled aircraft machine guns require ammunition that is strictly UNIFORM in dimension and weight, and that has a minimum variation in its ignition rate. Otherwise, with synchronized guns, you can see that a variation in the ignition rate of the powder might cause bullets to hit the propeller blades.

Ground machine guns, however, are of a more rugged construction than aircraft guns. Such close tolerances in the grading of their ammunition are not necessary.

Consequently, production orders and specifications call for the manufacture of ammunition for use in specific weapons. Such ammunition is manufactured in quantities called LOTS. Each lot is carefully tested by ordnance experts, and on a basis of the test results, the entire lot is GRADED to designate the type of weapon in which it may be used.

All ammunition has a LOT NUMBER, and the GRADE of each lot is published in a *Bureau of Ordnance Circular Letter,* issued each year.

Occasionally, a lot may be regraded or withdrawn

from service. Such facts are announced in special circular letters.

While every effort is made to issue the proper grade ammunition for use in each particular type of weapon, it is your duty to check the GRADE of each lot number by referring to the latest *Bureau of Ordnance Circular Letter* on the subject.

Here are the various grade symbols, and their meanings for caliber .30 and .50 ammunition.

AC—primarily for use in aircraft machine guns. This grade has a minimum variation in its rate of ignition, and it has a high uniformity in weight and dimensions. This grade is also suitable for ALL other types of machine guns.

MG—for use in ground machine guns ONLY. This grade ammunition is not sufficiently uniform for use in aircraft machine guns, but it is entirely suitable for use in the heavier ground-type guns.

R—This grade symbol refers to caliber .30 ammunition only. It is primarily for use in rifles and automatic rifles. The grading is based on minimum extraction effort and other factors. However, this grade is suitable for use in all machine guns EXCEPT aircraft machine guns.

*—This sign, placed beside the grade number, indicates that that particular lot is to have a priority in use.

3—A number "3" grade number indicates that that particular lot of ammunition is UNSERVICEABLE AND NOT TO BE USED.

Sometimes you will find that more than one grade will be authorized for certain lots. For example, if a lot carried the grade designation *AC (R)*, you would know that the lot was primarily for use in aircraft machine guns but that it could also be used in rifles, automatic rifles, and other types of machine guns.

The grades for caliber .45 ammunition are as follows:

Grade 1. SERVICE, for pistols, revolvers, and submachine guns.

Grade 2. TARGET, for pistols and submachine gun target practice only.

Grade 3. UNSERVICEABLE and not to be used.

Grade designations ARE NOT marked on ammunition packing boxes, and you will not find any grade designation accompanying a particular lot. This information appears only in *BuOrd Circular Letters.*

LOT NUMBERS

LOT NUMBERS are assigned to all types of service ammunition at the time of manufacture. A LOT of small arms ammunition may run from 200,000 to 1,000,000 rounds.

The component parts of each round—powder charge, case, and bullet are also given lot numbers when they are manufactured, but when these components are assembled into a LOT of ammunition, the LOT NUMBER assigned to the finished ammunition identifies one combination of component lots assembled by one manufacturer under uniform conditions.

Any one lot of ammunition should give uniform performance during its serviceable lifetime.

Why is the lot number so important? Because it is the one means by which all service ammunition is identified. For example, suppose you break out a new lot of ammunition and find it contains a number of cracked cartridge cases. In order to have that particular lot withdrawn from service, you report the facts, referring to the ammunition by lot number.

Now if you report the lot number incorrectly, a large quantity of serviceable ammunition might be

condemned, whereas the lot that SHOULD be condemned would continue to be authorized for use.

The lot number is PLAINLY MARKED on all packing boxes, and unlike grade designations, is NEVER CHANGED. Once a lot number is assigned, it remains as the permanent number of that particular lot.

You can see that it would be impractical to mark the ammunition lot number on each individual cartridge. Therefore, when you break out a new lot of ammunition and remove the cartridges from their original packing, you must keep track of the lot number until all of the cartridges are expended.

Cartridges whose lot numbers have been lost are placed in GRADE 3, but the action is taken only after every effort has been made to identify them by lot.

IDENTIFICATION

When you are reporting certain facts about ammunition, there is a definite form you follow in describing a certain lot.

Here are two examples.

Cartridges, Ball, Caliber .30, M2, W.C.C., 6090
Cartridges, A.P., Caliber .50, M2, F.A., 477

In the first example, "W.C.C." refers to the manufacturer—the Western Cartridge Company—and "6090" is the lot number.

In the second example, "F.A." means Frankford Arsenal, and "477" is the lot number.

The "M2" in both cases refers to the MODEL. Prior to 1925, the YEAR in which the model was adopted was used as the model designation—as "M1911". Today, however, when a model is adopted, it is assigned an arbitrary number, as "M1", or "M2".

Not only is it important for you to know how to describe a lot of ammunition correctly by using the proper designations, but it is equally important for you

to be able to recognize a particular type of ammunition by one look at the box in which it is packed.

The caliber, the type of bullet, the model designation, the manufacturer, the lot number, and the number of cartridges contained in each box are plainly marked on the box.

In addition, colored bands, identifying the TYPE OF BULLET packed in each box are printed on the sides and ends of each box to help you identify each type quickly. The WIDTH of these bands varies with the CALIBER of the ammunition.

On caliber .30 and .45 ammunition boxes the band is painted HORIZONTALLY on the SIDES, and VERTICALLY on the ENDS. The band on a caliber .30 box is WIDER than the band on the caliber .45 box.

On boxes for caliber .50 cartridges the bands are painted DIAGONALLY on BOTH the ENDS and the SIDES.

The colors of these bands for each type of bullet are as follows:

BULLET TYPE	COLOR
Ball	Red
Blank	Blue
Dummy	Green
Armor Piercing	Blue on Yellow
Tracer	Green on Yellow
Incendiary	Red on Yellow

When cartridges have been removed from their packing boxes, you can still identify them EXCEPT for their lot number and grade designation.

The initials of the manufacturer and the year of loading are stamped on the head of the cartridge, and you can identify the bullet type by the following markings on the bullet tip:

BULLET TYPE	MARKING
Ball	Plain, no marking
Tracer	Red tip
Armor Piercing	Black tip
Incendiary	Light blue tip

Look at figure 11. There you see illustrated the manner in which the various bullets are marked.

Sometimes the tips of machine gun bullets are smeared with colored lithographic INK so that hits can be identified when several guns are firing on the same target. Bullets so marked will leave a smear as they pass through the target. If one gun is firing bullets marked with blue ink and another is firing bullets

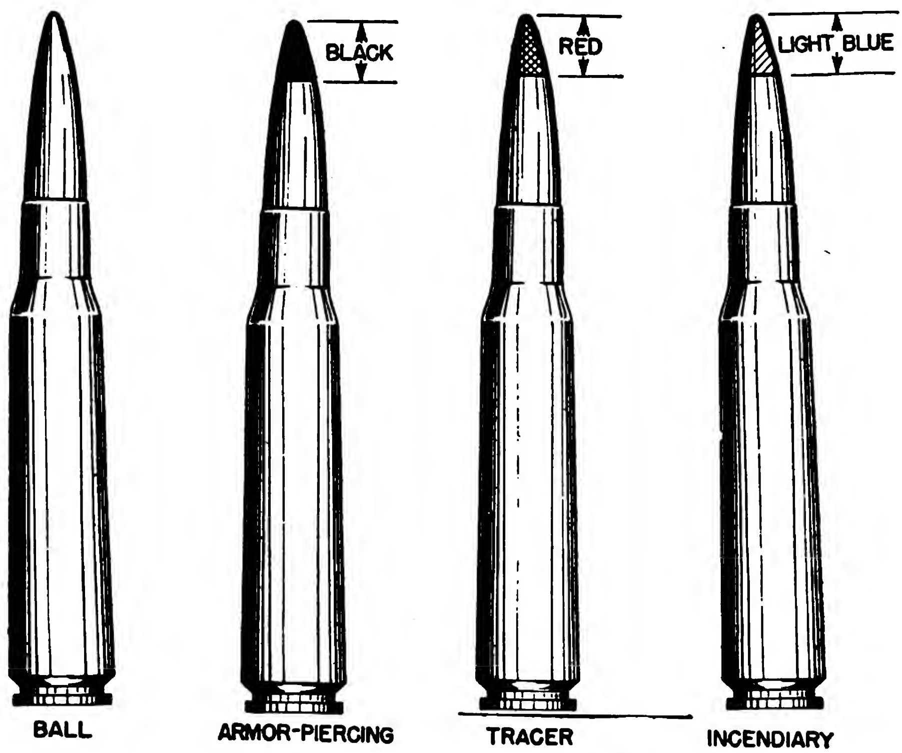


Figure 11.—Bullet color identification.

marked with red, you can credit hits to the proper gun crew. Don't confuse this type of marking with the PAINTED markings illustrated above, however.

HOW SMALL ARMS AMMUNITION IS PACKED

Small arms ammunition is packed in sealed metal-lined wooden cases of uniform size. The same size boxes are used for both caliber .30 and caliber .50 ammunition.

Inside the boxes, ammunition is packed in either cartons, clips and bandoleers or in clips and cartons. A bandoleer is an olive drab cotton ammunition belt with six pockets for carrying rifle ammunition.

One caliber .30 machine gun ammunition case contains 1,500 rounds when packed in cartons—20 cartridges to the carton and 75 cartons to the case.

One caliber .50 ammunition case contains 350 rounds packed in cartons of 10 rounds each—35 cartons to the case,

Caliber .45 ammunition is packed in cases of slightly different size and shape, with 2,000 rounds packed in 100 cartons of 20 rounds each.

Caliber .30 ammunition for carbines is packed in cases similar to caliber .45 cases, with 2,700 rounds to the case in 60 cartons of 45 rounds each.

STORAGE

Small arms ammunition is not as dangerous to handle as most other ammunition. But it is classed as a FIRE HAZARD because if it is exposed to fire, each cartridge explodes individually, and the case and the bullet fly in opposite directions. That's why, when fire occurs in a small arms magazine, it is advisable for everyone not actually fighting the fire to keep at least 200 yards away from the blaze.

Because small arms ammunition is packed in metal-lined boxes, it is easy to handle and to stow.

First of all, DON'T SLING THE BOXES AROUND. A broken box probably means that the metal liner has been punctured too, and even a small puncture will admit a lot of moisture in a damp climate. But if any boxes are unavoidably damaged, repair them immediately, and make sure that all markings are transferred to the rebuilt box.

Next, always protect the ammunition from damp-

ness and extreme heat. Always store it UNDER COVER, away from steam pipes and skylights through which the direct rays of the sun might strike. The combination of high temperatures and dampness is especially harmful and, over a period of time, will cause the powder to decompose. Tracer ammunition, in particular, will deteriorate rapidly if exposed to dampness. In some cases, it may even ignite spontaneously.

If, due to operating conditions, you find it necessary to store ammunition out-of-doors, you should raise it on dunnage at least 6 inches from the ground and cover it with a double thickness of tarpaulin. Also, dig drainage trenches to prevent any water from flowing underneath the pile.

Whether you are storing ammunition indoors or out, however, always stow and stack it according to caliber, type, and lot number. NEVER mix several lots of ammunition in one pile.

BREAKING OUT AND INSPECTING NEW ROUNDS

Never open a box of ammunition nor break its metal liner until the ammunition is to be used. When ammunition is removed from its sealed container in a damp climate, the brass cartridge cases are apt to corrode and become unserviceable if the ammunition is exposed for any length of time. Also, the lot numbers of loose ammunition are very likely to become lost.

Never open a box by destructive force. Instead, break the seals, unscrew the wing nuts and lift off the cover of the outer box. Next, lift off the cover of the metal lining. If it sticks, place a piece of wood inside the handle to get a better grip, and jerk the cover loose with an angular pull. Boxes are used over and over again as long as they are serviceable.

Defective ammunition is one of the most frequent causes of malfunctioning in aerial machine guns. Con-

sequently, if you inspect all ammunition carefully before loading it into belts, you can often prevent a machine gun stoppage caused by a defective round in the belt. You should inspect all loose ammunition as often as possible. Be particularly careful to check over all older lots and lots which have been subjected to unfavorable storage conditions.

Primarily, inspection is merely a matter of LOOKING for defective rounds. On careful examination, you can quickly spot cracks in cartridge cases, burrs on the extracting grooves, loose bullets, dents in the cases, recessed or protruding primers, long and short rounds, and so forth.

By standing cartridges on their heads, you can check for short and long rounds. When you suspect that a cartridge head is not of the correct thickness, take a new, spare machine gun bolt and pass the extracting rim through the T-slot. Heads that are too thick or too thin will show up under this test.

You need not spend too much time inspecting belt links because you would see right away any links that are corroded, rusty, or bent. Also, when cartridges are forced into the belt links by the link loading machine, defective links usually show up at once.

When you load ammunition into belts, always tag the belts with the ammunition lot number if you think there is a chance that you may have to unbelt the cartridges and return them to their boxes.

Always wipe any sand or dirt or water off the ammunition without delay. Never polish cartridges to improve their looks, but if a light corrosion forms, clean it off with a dry cloth.

NEVER apply grease or oil to cartridges to be used in a high-pressure weapon. Grease and oil pick up grit and dust which will injure the gun mechanism. Also, a dry cartridge, when fired, expands under the pressure of the burning powder and adheres to the chamber,

thus relieving the face of the bolt from a considerable amount of pressure. When a cartridge is greased, the case will not adhere to the chamber. It slips backward, causing dangerous pressure against the face of the bolt.

Occasionally you will be required to test-fire a rifle or a machine gun. If the gun misfires—that is, if you pull the trigger and you hear the click of the firing pin but nothing happens—DON'T OPEN THE BOLT FOR AT LEAST 10 SECONDS, since it may be a HANGFIRE. With a hangfire, there is an appreciable delay between the time the primer strikes the firing pin and the time the powder charge explodes. If you open the bolt immediately, the charge may explode in your face.

Whenever practical, you should save all empty cartridge cases, used clips, bandoleers, empty packing cases with their liners, and turn them in for reuse or for scrap salvage. Make certain that no live rounds are mixed in with the material, however, or someone may be in for trouble.

20 mm AMMUNITION

20 mm aircraft cannon ammunition, like caliber .30, .45 and .50, is FIXED ammunition. Each round is loaded, fired, and the cartridge case extracted and ejected automatically.

Both the M1 and M2 models of the gun fire the same ammunition.

The cartridge case, primer, and propellant of 20 mm ammunition are basically the same as the caliber .30, .45 and .50, except that the 20 mm round is larger.

There are THREE types of projectiles in 20 mm ammunition—HIGH EXPLOSIVE INCENDIARY (HEI), ARMOR PIERCING (AP), and PRACTICE.

Look at figure 12. This illustration gives you the overall dimensions and the characteristic color mark-

ings of the HIGH EXPLOSIVE INCENDIARY 20 mm cartridge.

This cartridge differs from all others that you have so far studied in that it has a nose FUZE. The fuze is ARMED as the projectile is fired from the gun, and when the fuze strikes the target, it detonates the explosive FILLER in the projectile.

The details of fuze operation, the type of explosive filler used, and the fine points of the HEI projectile are classified as CONFIDENTIAL, hence they cannot be detailed in this book. Enough general information can be given to you, however, to enable you to recognize its principal characteristics.

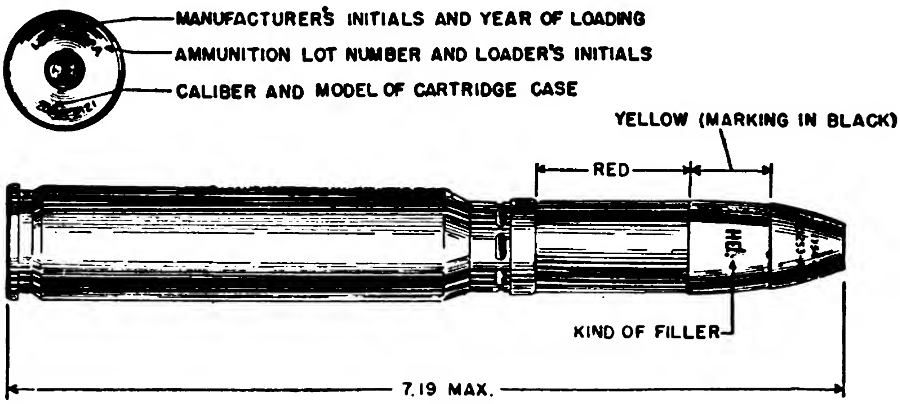


Figure 12.—20 mm HEI cartridge.

The FUZE is made of brass. It is threaded into the nose of the projectile and staked by driving the metal of the projectile into the fuze body in three places. On the surface of the fuze is stamped its lot number, its nomenclature, and the initials of the manufacturer.

NEVER, under any circumstances, attempt to DISASSEMBLE a fuze unless you have received specific instructions to do so originating from the Bureau of Ordnance.

The PROJECTILE, or shell body, is made of cold drawn steel. Two recesses are machined into its surface. One is the CANNELURE, into which the mouth of the

cartridge case is crimped to hold the projectile firmly in place. Into the second recess, a ROTATING BAND, made of copper tubing, is pressed. This band presses firmly against the rifling in the barrel as the projectile leaves the gun and prevents the explosive gases from leaking past the projectile. Copper being a much softer metal than steel, this band prevents the excessive wear on the gun barrel interior which would result if the steel surface of the projectile were in direct contact with the barrel.

At its base, the shell body is only .15 in. thick, so to prevent a premature detonation of the explosive filler, a base cover of sheet steel is welded to the shell body.

The ARMOR PIERCING projectile is similar in shape to the HEI projectile. It is made of solid steel and carries a tracer charge in its tail which is ignited by the propellant charge.

PRACTICE ammunition, as the name implies, is used for practice and proof firing. It is completely inert, hollow, and has no trace, but in shape and ballistic properties it is very similar to the HEI. In fact, it is designed to simulate the HEI for practice purposes.

IDENTIFICATION

The LOT NUMBER is stamped on every round of 20 mm ammunition, as well as on the packing case and on the accompanying ammunition data card.

As you know, primers, propellants, projectiles and fuzes each are assigned lot numbers when they are manufactured. All the rounds of any one LOT of 20 mm ammunition are assembled from components of the same lots, so you should try to load all successive rounds with ammunition of the same lot number for maximum accuracy of fire.

A 5″x8″ ammunition data card is packed in each ammunition box. Occasionally you will find certain

firing instructions printed on the reverse side of these cards.

The projectiles, being steel, are painted to prevent rust—and, incidentally, to provide a means of easy identification. The following colors are painted on the various types of ammunition:

High Explosive Incendiary	Yellow Ogive—red body
Armor Piercing	Black
Practice	Black

The following information is marked or stamped on the ammunition.

ON THE PROJECTILE
Kind of filler (for example, HEI)
Loader's lot number
Loader's initials and symbol
Year of loading

ON THE FUZE (HEI only)
Model and designation
Manufacturer's initials
Loader's lot number
Year of loading

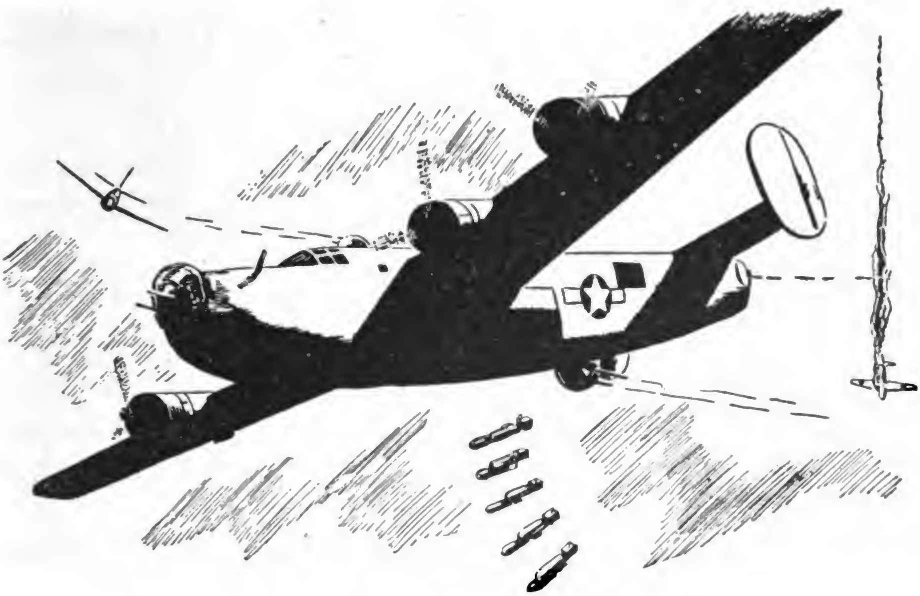
ON BASE OF CARTRIDGE CASE
Lot number and loader's initials (stencilled)
Caliber and designation
Manufacturer's initials or symbol
Year of manufacture

HANDLING

You should follow the same precautions with 20 mm ammunition that you observe in handling caliber .30, .45 and .50 ammunition—EXCEPT that you must exercise EVEN GREATER CARE IN HANDLING the 20 mm HEI because of its sensitive fuze.

NEVER disassemble a fuze nor handle a DUD. The fuzes of duds are ARMED and are extremely dangerous.

As you know, ALL ammunition must be protected from heat and moisture, and 20 mm is NO EXCEPTION.



CHAPTER 3

BOMBS

BOMBS AWAY

"Target sighted."

"Bomb bay doors open."

The airplane settles into her bombing run while puffs of flak thicken around her. The target appears in the bombsight eyepiece, wavers back and forth across the centerline, and settles under the crosshairs as they begin to track it down the field of view. A few more seconds and the airplane lurches as the bombs fall away. The bombs wobble, then swing smoothly into the long curve down towards enemy territory.

"Bombs away."

As the bomb bay doors begin to swing shut, the airplane breaks violently into evasive action.

America's Sunday punch is on the way.

Some people say the bomb is the most effective single weapon of modern war. It sinks ships, destroys air strips and wipes out whole cities. It is heavy artillery which can range as far as an airplane can fly.

And yet a bomb is a very simple thing—hardly more

than a steel box filled with explosives. If you understand it and handle it right, it is safe to work with and will do a real job on the enemy.

If you don't understand it, if you don't treat it right, it will very likely end up as a useless dud—if it doesn't blow you to pieces first.

That isn't just theory either. American bombing operations show FAR TOO HIGH a percentage of duds—higher than that of any other major air force in this war. And the main reason for that is that American ordnancemen aren't CAREFUL enough in dealing with bombs and the fuzes that go into them.

And as a result of that same carelessness, there have been a number of very serious accidents in recent years at Naval air stations—accidents in each of which dozens of men have been killed.

Figure 13 shows a typical bomb dressed to kill and ready to go.

Mounted fore and aft on the BOMB BODY you see two FUZES, known as the nose and tail fuzes. These are the mechanisms that explode the bomb at the right moment. They screw into recesses—or FUZE POCKETS—which are provided at the nose and tail of the bomb. Either one of them alone can do the work, but two are usually used to make doubly sure that the bomb will go off when it should.

Further aft you see the TAIL ASSEMBLY or stabilizing fins. This tail, a comparatively light sheet metal affair, is what makes it possible to aim the bomb. Because of it, the bomb falls in a smooth definite curve instead of tumbling wildly through the air. If the tail is dented or bent, the bomb will fall in a cockeyed path and land "off-target." This is an important thing to remember whenever you are handling bombs, because bombardiers sometimes become quite annoyed at ordnancemen who make them miss targets by bending a fin.

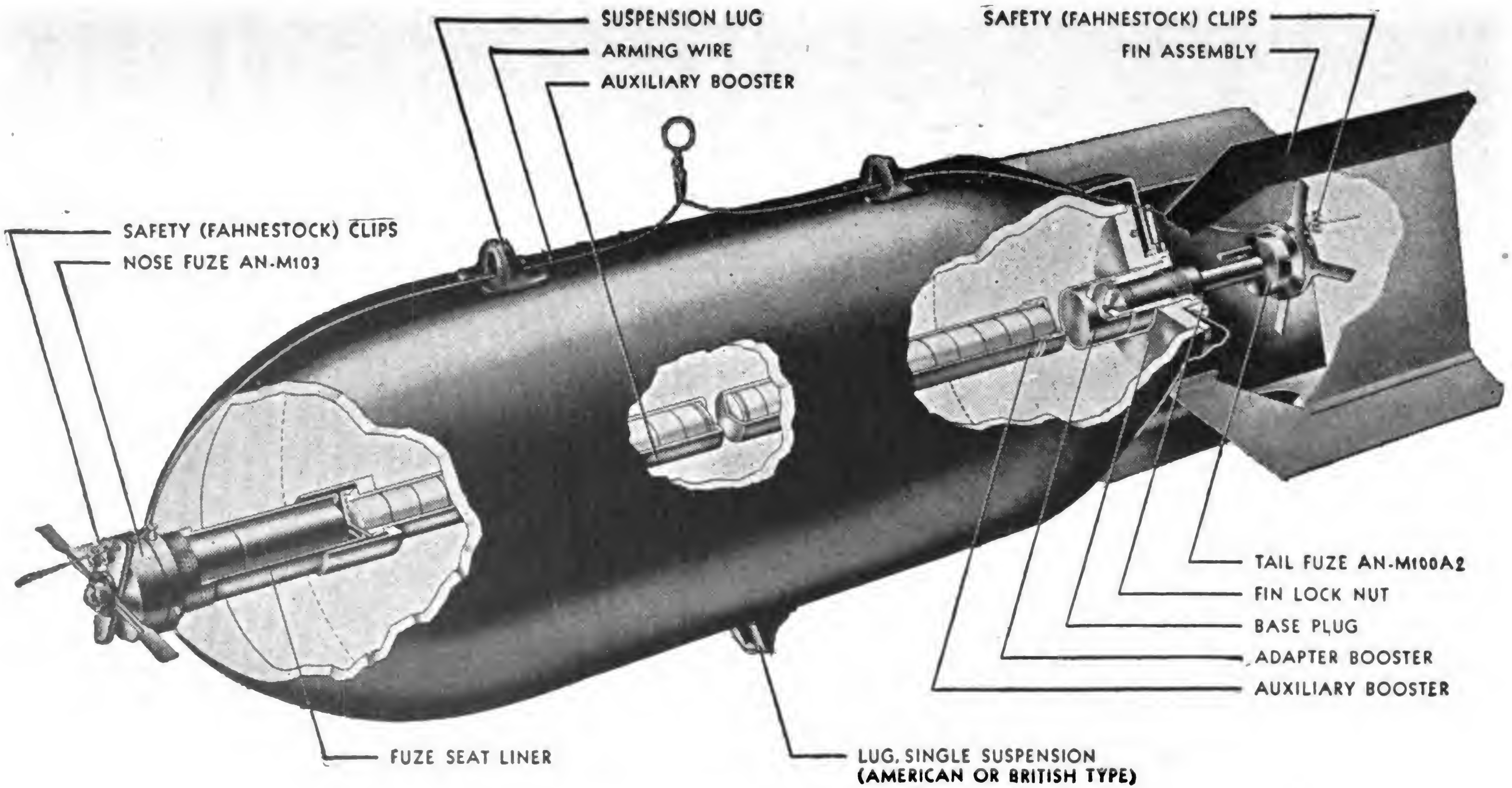


Figure 13.—General purpose bomb assembled for loading.

The tail is attached to the bomb by means of the FIN LOCK NUT you see screwed to the rear of the bomb.

Running along the top of the bomb body you see the ARMING WIRES. These wires are used to foul the little propellers or ARMING VANES of the fuzes and prevent them from rotating while the bomb is suspended in the airplane.

The bomb body itself is a cylindrical steel case curved to a streamlined shape at the nose and tapering slightly in the rear. You can see from the figure that the case has a threaded opening in the nose to receive a fuze. At the rear is a large opening through which molten explosive is poured at the loading plant. Before the bomb is shipped to the fleet, this opening is closed by a sort of cover called the BASE PLUG, which is screwed on and firmly staked in place. The base plug has a threaded projection designed to receive the tail locking nut.

In the center of the tail closing plate is a threaded hole into which a tube—called the ADAPTER-BOOSTER in some bombs and the FUZE SEAT LINER in others—is screwed. This tube is threaded on the inside so that the tail fuze can be screwed into it.

Two auxiliary boosters inside the bomb help the fuzes set off the main charge.

WHAT A BOMB DOES

How does a bomb work? That sounds easy to answer—"it explodes and all hell breaks loose."

But it's not quite as simple as that. A lot happens to a bomb when it hits a target. And its behavior depends on how it's built and how it is loaded.

Here is a bomb—a steel case filled with high explosive—falling through the air. It hits the roof of a building. Instantly the case of the bomb takes a terrific jolt. If the case is THIN—and some bombs do

have thin cases—it may actually break under the impact. If that happens, it's the end of the useful life of that bomb. As you learned in chapter 1, an explosive must be confined if it is to produce a high-order explosion. If the case breaks, the explosive is no longer confined.

But suppose the case of the bomb is strong enough to withstand the impact. Then the bomb will PENETRATE the roof of the building and plunge inside. There at some point, it will explode—if the ordnancemen did a good job of getting it ready.

The explosive filling of the bomb detonates—and is transformed suddenly into gas. Because the gas is confined inside the casing of the bomb, it builds up a terrific heat and pressure—a pressure about 10,000 times that of the normal atmosphere. Within a fraction of a second this pressure has become so great that the case of the bomb is splintered into pieces. Driven by the immense pressure behind them, these pieces fly outward in all directions at about twice the speed of a machine gun bullet. The red hot fragments will pierce walls, break holes in machinery, kill anyone they hit. This way of doing damage is known as FRAGMENTATION.

When the bomb casing is ruptured, the compressed gases inside fly outward and strike a hammerblow against the surrounding air. The air is compressed by the blow. Trying to expand, this compressed air in turn compresses the air around it. Thus a WAVE OF HIGH PRESSURE travels outward through the air in all directions from the explosion.

In a fraction of a second, this wave reaches the wall of the building. The air on one side of the wall is put under very high pressure. On the other side of the wall, the air is under atmospheric pressure only. Therefore, a great push is exerted against the wall.

The push may knock the wall down, may blow a hole in it.

When the gases shot out of the ruptured bomb case, they left an empty space—a vacuum—behind them. So when the wave of pressure has passed, the air around the bomb rushes in to fill the vacuum. The air rushing in leaves a low pressure area where it was before, and the air around that moves in to fill the low pressure area. Thus a WAVE OF LOW PRESSURE travels outward just behind the wave of high pressure.

If the high-pressure wave leaves the wall standing, the low-pressure wave hits it next. Now the air inside the wall is at a very low pressure, while the air outside is at atmospheric pressure or a little higher. So a great pulling force is exerted against the wall.

With this one-two, push-pull action, a bomb can shake a whole building or ship the way a terrier shakes a rat.

This way of doing damage is known as BLAST.

Now you can see why there are so many different types of bombs. They vary in their PENETRATING power, their FRAGMENTATION effect, and their BLAST effect.

LOADING FACTOR TELLS THE STORY

A bomb with a thick heavy case, for instance, will be able to penetrate much further than a bomb with a thin case. But most of the WEIGHT of such a bomb goes into the case. It cannot carry as much explosive, and so it will have LESS blast effect.

If the walls of the case are thin, there will be room for lots of explosive. The blast effect will be great. But the case will have little strength, and the bomb will NOT penetrate. There won't be much fragmentation effect, either, from such a bomb. There just isn't enough metal in the case to provide many fragments.

If you know what percentage of the weight of a bomb is taken up by the explosive, you can tell quite a bit about the way it will behave and the kind of damage it will do. This figure is called the LOADING FACTOR of the bomb. It is the RATIO of the weight of explosive to the total weight of the bomb. If the total weight of a bomb is 1,000 pounds, say, and it contains 500 pounds of explosive, it will have a 50 percent loading factor. If it contains only 150 pounds of explosive, it will have a 15 percent loading factor.

Well then, what is the BEST loading factor for a bomb? That depends on what you want the bomb to DO. If you want to knock down a row of masonry buildings, you want the most blast possible. Therefore, you need a high loading factor. If you want a bomb which will get through the deck armor of a battleship, you need penetration power, and that calls for a low loading factor.

That is why bombs have been divided into many different types with different uses—general purpose bombs, armor-piercing bombs, semi-armor piercing bombs, depth bombs, fragmentation bombs—each with its own particular use.

THE JACK OF ALL TRADES

The most common type of bomb, as you would expect from the name, is the GENERAL PURPOSE or GP bomb. This is a sort of compromise bomb. It has good blast effect, fair penetration, and some fragmentation. It has a loading factor of about 50 percent. Its case is ¼ to ½ inch thick, depending on the size of the bomb. This gives it just enough strength to penetrate several decks of an un-armored ship or several floors of an ordinary building.

The bomb illustrated in figure 13 is a GP bomb.

Fifty percent is a pretty big loading factor, and the GP bomb does most of its damage by blast.

The explosive filling of GP bombs is either TNT or AMATOL. Amatol, you remember, is a mixture of TNT and ammonium nitrate. Amatol has just about as much explosive power as straight TNT and is a lot cheaper. It does have one important disadvantage—it tends to absorb moisture from the air. As the chemists say, it is hygroscopic. Therefore, the nose and tail ends of amatol-loaded bombs are filled with TNT. These TNT "surrounds" seal the amatol away from the air.

Because it is so often used, the general purpose bomb is available in a wide range of sizes. The smallest weighs 100 pounds and the largest 2,000 pounds. The GP bomb has a rounded nose, ordinary box tail, and pockets fore and aft to receive fuzes.

GETTING IN DEEPER

The GP bomb is usually the best bet against targets which are not armored or fortified. But sometimes you have to attack targets which offer some RESISTANCE to penetration. If the resistance is not too great, it is possible to use the SEMI-ARMOR PIERCING or SAP bomb. This bomb rather resembles the GP, but it has a thicker case and a correspondingly smaller amount of explosive.

Because of its heavier case, the SAP bomb can penetrate 2—2½ inches of armor plate, depending on the height from which it is dropped. This makes it a useful bomb against such targets as aircraft carriers, old heavy cruisers—and even large merchant ships, whose many decks might stop a GP bomb before it could get far enough in.

Does that mean that the SAP is a better bomb than the GP?

Not at all. In order to get its greater penetrating

power, the SAP bomb has to get along with a smaller quantity of explosive. It has a loading factor of only about 30 percent. It will get farther into the target than a GP will, but it won't do as much damage when it gets there. Also, the damage it does do will lean more to FRAGMENTATION and less to blast.

The SAP bomb is used by the Navy in two sizes—500 and 1,000 pounds. In appearance it generally resembles a GP bomb, except that it is slimmer. Like the GP bomb it is loaded with TNT or amatol. It has fuze pockets fore and aft, but the forward pocket is rarely used because the shock of impact against the armor would be so great as to wreck any nose fuze. Notice the steel nose plug in figure 23 on p. 76.

BOMBING THE BATTLEWAGONS

Every so often a mission comes along where what you want above everything else is PENETRATING power. In attacking a battleship or heavy cruiser, for instance, you have to get through many inches of deck armor. The ARMOR-PIERCING bomb has been developed for use against such targets.

This bomb has a really heavy case, running up to a thickness as great as 14 inches of steel at the nose. The nose section is heat treated for greater strength, and the outer surface of the bomb is carefully machined all over to reduce air resistance.

Because of its greater weight and smoother surface, the AP bomb falls about half again as fast as the GP bomb. In consequence it has much more hitting force when it lands and—since its case is strong enough to resist the impact—it will penetrate deep into armor plate. If the largest AP bomb is dropped from a sufficient height—about 14,000 feet—to develop its full VELOCITY, it will penetrate nearly 7 inches of armor.

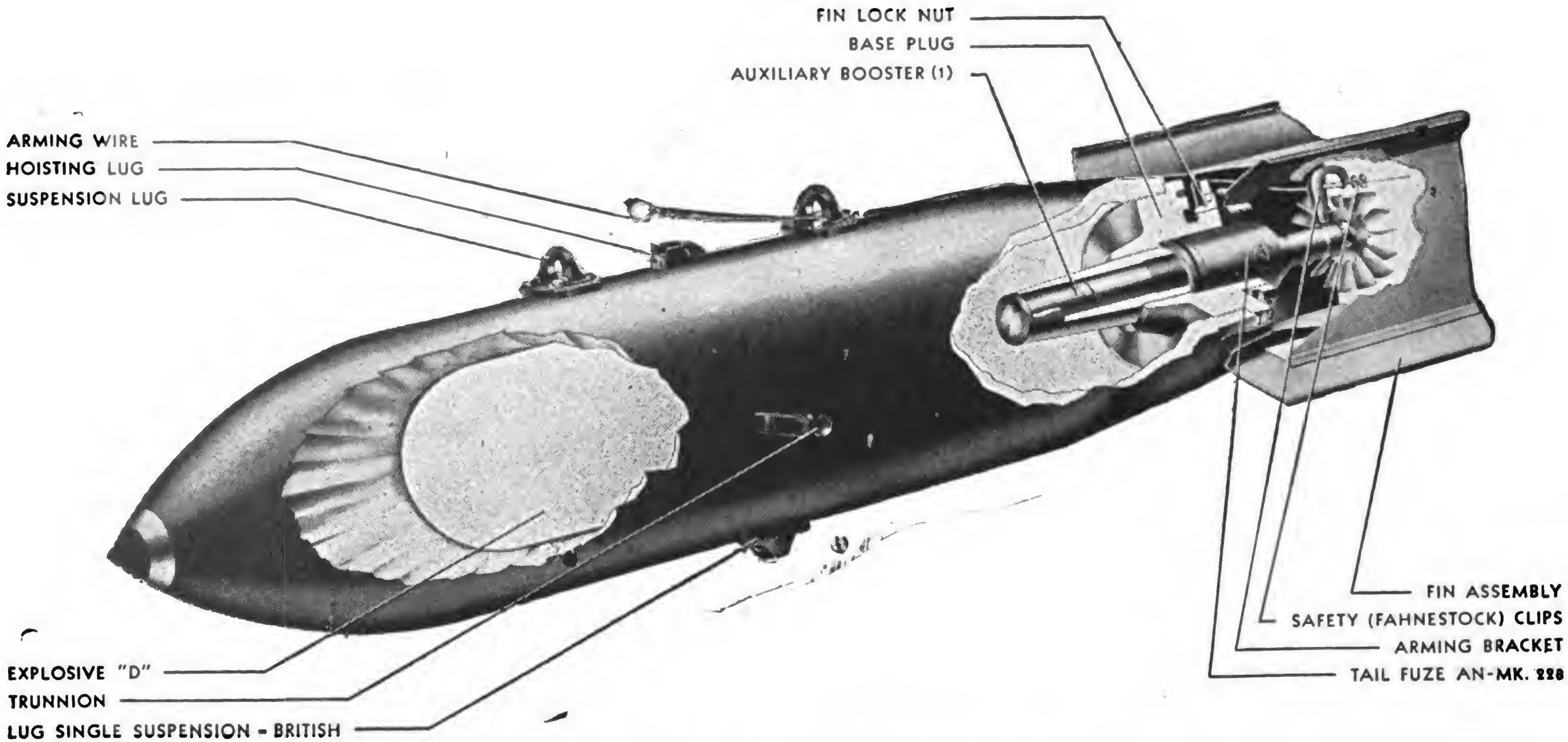


Figure 14.—Cut-away view of a 1000-lb armor-piercing bomb.

This is enough to get through the deck armor of the heaviest warships afloat.

If the bomb is dropped from a lower altitude, as in a dive bombing attack, it loses a great deal of its penetrating power. In a normal dive bombing attack with release at 3,000 to 4,000 feet, the bomb can pierce no more than 4 inches of armor plate.

With its heavy case, the AP bomb necessarily has a very LOW loading factor—about 14 percent. Its actual explosive power is even less than this loading factor would indicate, because it uses a less powerful explosive—EXPLOSIVE D. Even though TNT and amatol are pretty insensitive, the shock when an AP bomb strikes armor plate is so great that these explosives would go off spontaneously before the bomb had a chance to penetrate the armor. Explosive D is even less sensitive than TNT and can resist the impact. But it is also less powerful.

An AP bomb, therefore, has practically NO blast effect. When it penetrates the interior of a ship and explodes, it does all its damage by FRAGMENTATION. The case is shattered into several hundred large chunks of metal which are sent whizzing about, and while this does less damage by and large than blast would do, it still results in a lot of wreckage.

Another effect of the low loading factor is that an AP bomb has no NEAR MISS effect. When a large GP bomb just misses a ship and goes off in the water alongside, the explosion of the bomb will send a wave of pressure traveling through the water. This pressure, hammering against the hull of the ship, can do great damage.

Often a near miss with a GP bomb will do as much damage as a direct hit—or even more. An AP bomb, however, has so little explosive in it that an explosion in the water alongside has no effect. With an AP bomb, a miss really is as good as a mile.

The AP bomb is used in two sizes—1,000 pounds and 1,600 pounds. In external appearance they resemble slim GP bombs except for the absence of the nose fuze pocket and a more pointed nose.

ANTI-PERSONNEL BOMBS

Still another bomb with a low loading factor is the FRAGMENTATION bomb. Here, the purpose of the low loading factor—10 to 15 percent—is not increased penetration. Instead, it is intended to increase the fragmentation damage done by the bomb.

Blast is an excellent way of knocking down buildings and structures, but it is not so good for killing people. A pressure wave through the atmosphere is rarely fatal, but a slug of iron in the innards very frequently is. So, when you are chiefly interested in killing people, you drop a bomb designed to produce a large number of small FRAGMENTS whizzing around at high speed.

This is done by taking a rather small bomb with a thin case and wrapping a square bar of steel around it in a coil. When the TNT filler of the bomb explodes it will splinter this coil of iron into thousands and thousands of little fragments. So many fragments are produced that anyone standing within 40 yards of even a 20 pound fragmentation bomb cannot avoid being hit by at least one fragment.

A stabilizing fin or a parachute is attached to the rear of the bomb so that it will fall nose down.

"Frag" bombs, as they are sometimes called, range in size from 4 pounds up to 260 pounds, and bigger ones are being developed. Instead of being dropped singly, frag bombs are usually dropped in clusters. That is, three or six bombs are lashed to a framework of steel tubing, called an adapter, and the adapter is suspended from the plane. Over the target the whole

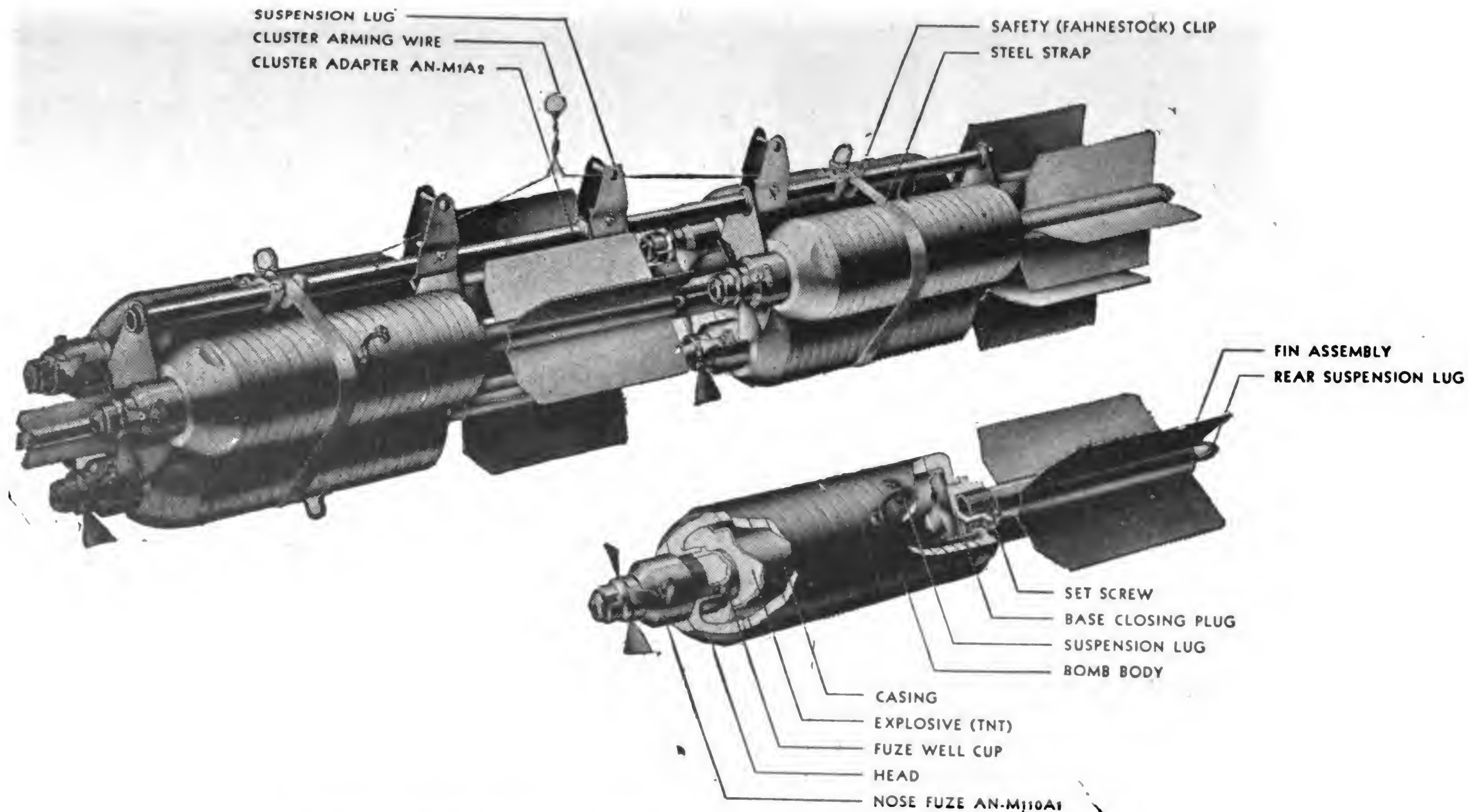


Figure 15.—A cluster of 20-lb. fragmentation bombs with stabilizing fins.

cluster is dropped, the lashings which hold the bombs to the adapter are loosed as the adapter is released from the plane, the bombs separate in the air, and they fall spread out over a wide area.

Some frag bombs have a parachute case attached aft instead of a tail. When the bombs leave the cluster, the parachute opens out and the bombs descend slowly. You can drop these bombs from altitudes as low as 70 feet. If a bomb were dropped from such a low altitude without a parachute, the plane would still be directly overhead when the bomb exploded, and the bomb fragments would kill the airplane's crew as well as the enemy. Except in the largest size, frag bombs carry

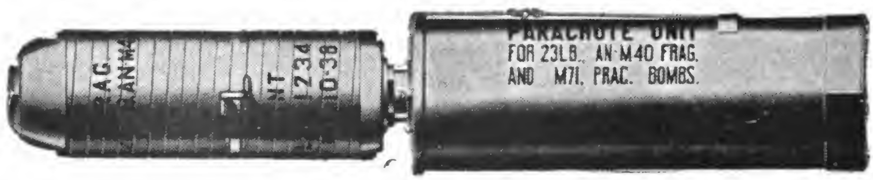


Figure 16.—A 23-lb. fragmentation bomb. The tube at the rear is the parachute case.

only one fuze, in the nose. Usually the bombs are shipped already fuzed.

DEPTH BOMBS

Against some types of targets you are not concerned at all with penetration or fragmentation effect. What you want is blast and blast alone. One such target is a submerged submarine.

There is practically no chance of a bomb actually hitting a submerged submarine. All you can hope for is that the bomb will explode reasonably close to it. Then the explosion will send a wave of pressure—a blast wave—through the water. If the explosion is close enough, it will stave in the side of the sub.

The bomb that you use is the DEPTH BOMB. A depth bomb has no need of a strong case, because it rarely

hits anything but water. Fragmentation would be useless, because the fragments would be slowed as they moved through the water. What is wanted is maximum BLAST effect. And that calls for the maximum amount of explosive.

Hence, the depth bombs have a thin case and a LOADING FACTOR of about 70 percent. They are sometimes loaded with TNT and sometimes with torpex. Torpex is about 50 percent more powerful than TNT. Unfortunately it is more sensitive than TNT and is more likely to explode if, say, a bullet is fired through it.

Torpex, usually called TPX, is much more sensitive than TNT. TPX-loaded bombs, therefore, must be handled with special care and not be dropped or jarred. As a matter of fact, all depth bombs need to be handled VERY CAREFULLY because their thin cases are easily dented or cracked.

Depth bombs are easy to recognize. They are shorter and fatter and, unlike other American bombs, they have ROUND instead of square tails. Most depth bombs, moreover, have an ATHWARTSHIP'S fuze pocket—a hole running crosswise through the bomb into which a fuze can be inserted.

This athwartship's pocket takes a special HYDROSTATIC fuze designed to detonate the bomb when it reaches a certain depth of water.

In addition, all depth bombs have a nose fuze pocket to take a fuze which will detonate the bomb on impact. This provision is made for an impact fuze because depth bombs are sometimes dropped on surfaced submarines, or other surface craft, and even on ground targets where a maximum blast rather than penetration or fragmentation is wanted. When a depth bomb is dropped in the normal fashion, to go off under water, the nose fuze is omitted or is dropped SAFE—fixed so that it will not operate.

Besides the nose and athwartship's pocket, large

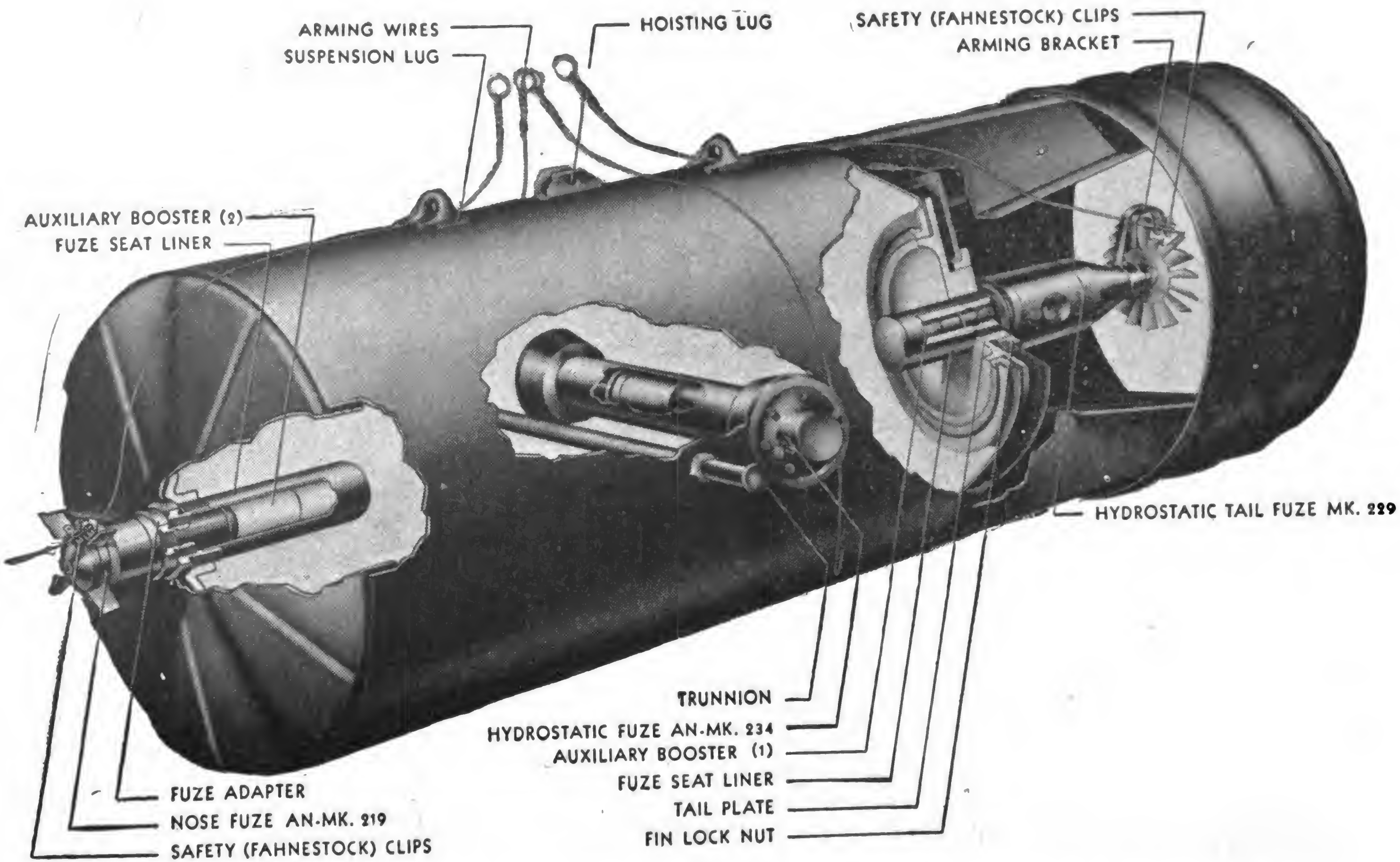


Figure 17.—A 700-lb. depth bomb. Notice the athwartship's fuze pocket and the round tail.

depth bombs have a tail fuze pocket to receive a second hydrostatic fuze.

Older depth bombs have round noses but the newer ones have FLAT NOSES. This flat nose makes the bomb less likely to bounce when it hits the surface of the water. False noses of sheet metal, known as FLAT NOSE ADAPTERS, can be fastened to the old round-nose bombs to convert them to a flat-nose shape. The hollow space under the adapter is filled with plaster of paris so that it will not crumple when it hits the water.

Depth bombs are made in TWO sizes. The smaller size weighs 325 pounds when loaded with TNT, 350 when loaded with TPX. The larger size weighs 650 pounds with TNT and 700 pounds with TPX.

WHAT ARE BLOCKBUSTERS?

Another type of thin case bomb is the famous BLOCKBUSTER. Blockbusters are large bombs—running from 4,000 up to 16,000 pounds with thin cases and a loading factor in the neighborhood of 75 percent. As you can figure out, they are designed for maximum BLAST effect, such as knocking down heavy masonry buildings. They are beginning to be used by the Navy and are widely used by the British in their saturation raids on Germany.

The 4,000-pound blockbuster made in this country looks like an over-sized GP bomb, except that the case is welded of steel plate. The British make larger ones which are flat fore and aft and look like boilers.

CHEMICAL BOMBS

The bombs you have read about so far are HIGH EXPLOSIVE bombs which do their business by exploding the filler and creating blast or fragments or both. Two

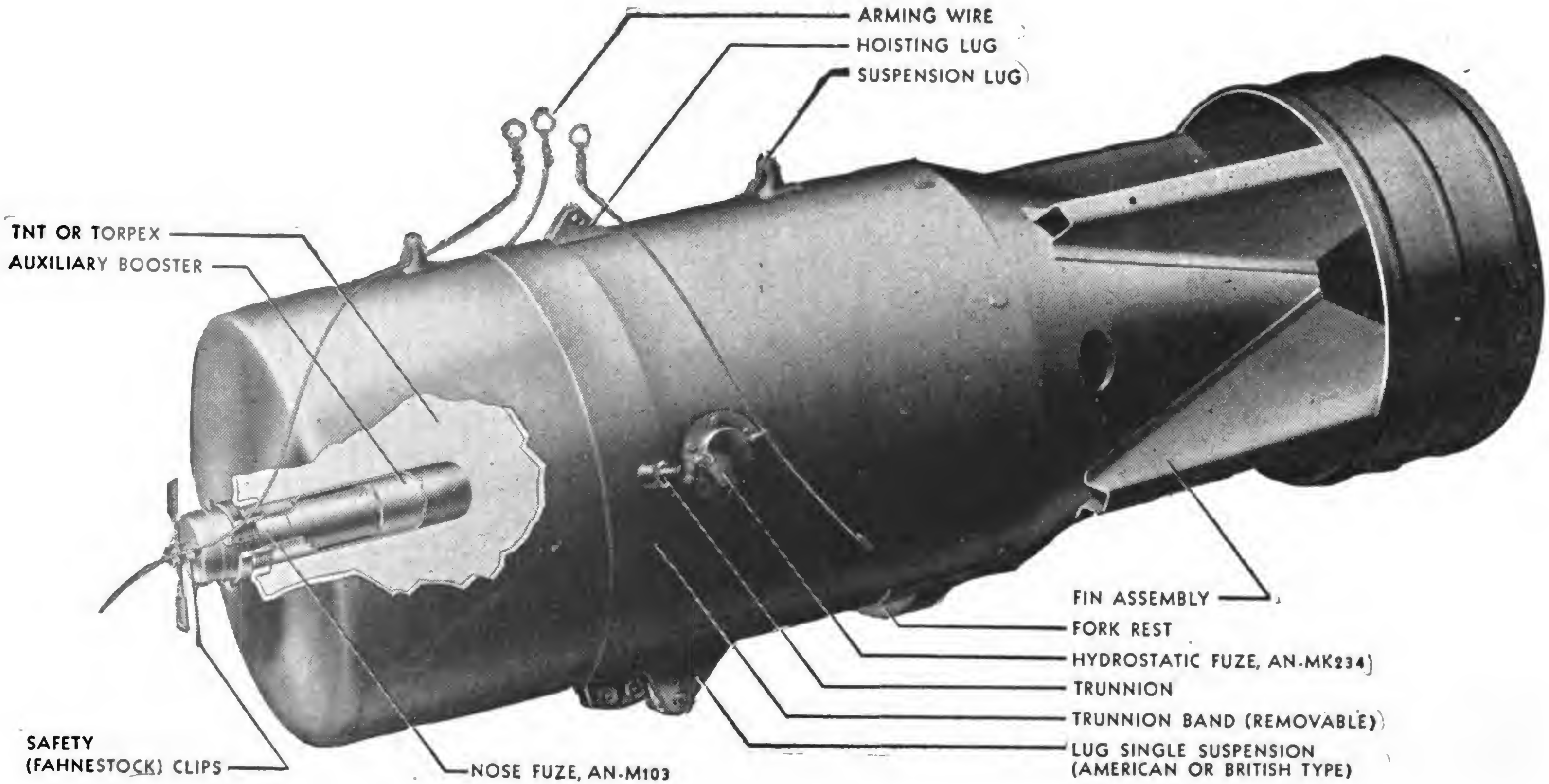


Figure 18.—A 350-lb. depth bomb. It has no tail fuze.

other types which you may come to know are chemical and incendiary bombs.

CHEMICAL BOMBS, as the name implies, are bombs loaded with poison gas—usually mustard or lewisite. Chemical bombs are made in a 100-pound size only, with a case that closely resembles that of a 100-pound GP bomb. Running through the center of the bomb is a tube filled with TETRYL. The rest of the inside of the bomb is filled with poison gas in liquid form. When the bomb hits the ground, a nose fuze explodes the tetryl, rupturing the case and throwing the mustard or lewisite around for a distance of about 100 feet. Chemical bombs have not been used so far in this war, but they are stored in large quantities—just in case.

BURNING THEM UP

When you want to start fires in enemy territory, you will meet two distinct types of target. You may be aiming at light combustible structures such as the temporary buildings around an airfield on a Pacific island. Or you may be trying to set afire solid, permanent buildings such as are found particularly in cities in the European theatre. Corresponding to these two types of target, you will find two types of incendiary bombs.

Against light inflammable targets, incendiary bombs filled with a GASOLINE composition are used. Sometimes this is gasoline to which a chemical has been added to make it JELL. Other times it is gasoline in which rubber has been dissolved to produce a sticky combustible material something like rubber cement. In either case, the incendiary filler is ignited and scattered around when the bomb strikes. It sticks to the sides of buildings, tents, and the like, and sets them afire. Because of the scattering action of this type of bomb, it is called a SCATTER INCENDIARY.

Two types of scatter incendiaries are now in com-

mon use. The large one is a 100-pound bomb. It has a case made of light sheet metal about 1/32 of an inch thick. Tail fins are welded to it. Like the chemical bomb, this bomb has a burster tube loaded with black powder running through the center. When the bomb is dropped, a nose fuze explodes the black powder charge, which ruptures the case, sets the incendiary filling afire, and scatters it around. These bombs are shipped to depots and stations empty, and the incendiary filling is put in by ordnancemen before the bomb is used. A filling hole with a removable cap is provided for this purpose.

These bombs must be handled with GREAT CARE to avoid denting the thin case.

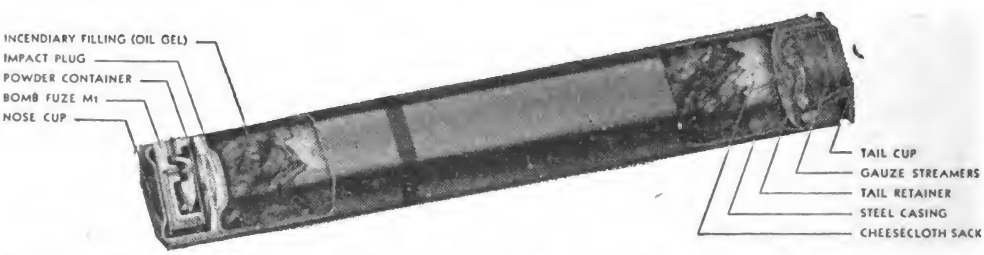


Figure 19.—A 6-lb. scatter-type incendiary bomb. It is always dropped in clusters.

Now coming into more common use is a smaller scatter incendiary weighing only 6 pounds. It is dropped in clusters like frag bombs. Its body is simply a hexagonal tube of sheet iron with square ends. It has no tail, but cloth streamers are fastened to it aft in order to keep it heading nose downward as it falls. The bomb, which is shipped loaded, contains a small charge of black powder in the nose and a filling of scatter type incendiary material. When the bomb hits, a built-in fuze explodes the black powder, which ignites the incendiary filling and blows it out the after end of the tube.

INTENSIVE INCENDIARIES

The scatter incendiary is fine against light targets, but a little burning gasoline around substantial buildings would be unlikely to start very serious fires. Against such targets, a much punchier incendiary, known as the INTENSIVE type, is used. This is a small bomb which burns for several minutes at temperatures in the neighborhood of the melting point of steel. Anything near it which can possibly burn will be set afire.

Only one bomb of the intensive type is now in regular use. This is a small bomb weighing 4 pounds which is always dropped in clusters. This bomb also is a hexagonal tube. Instead of sheet iron, the case is made of MAGNESIUM—a very light weight metal which burns easily. The filling is THERMATE—a composition of aluminum powder and iron oxide (rust) which burns with an intense heat. It is very similar to the thermate used in welding. This bomb does not have a tail, but the after end of the body is made of sheet metal and is empty. This makes the bomb nose heavy and keeps it headed in the right direction as it falls.

When the bomb strikes, a built-in fuse ignites the thermate. The thermate filler and the magnesium body burn for 10 minutes or more at a temperature of nearly 2,500° F.

In each cluster of these incendiary bombs, every fourth bomb is loaded with an explosive charge which goes off after the bomb has burned for about 1.5 minutes. This charge, which is big enough to kill anyone near by, is intended to discourage people from trying to pick up the burning bombs with long-handled shovels. Incidentally, enemy incendiary bombs have this same feature. You should always wait at least 2 minutes before attempting to deal with an incendiary bomb.

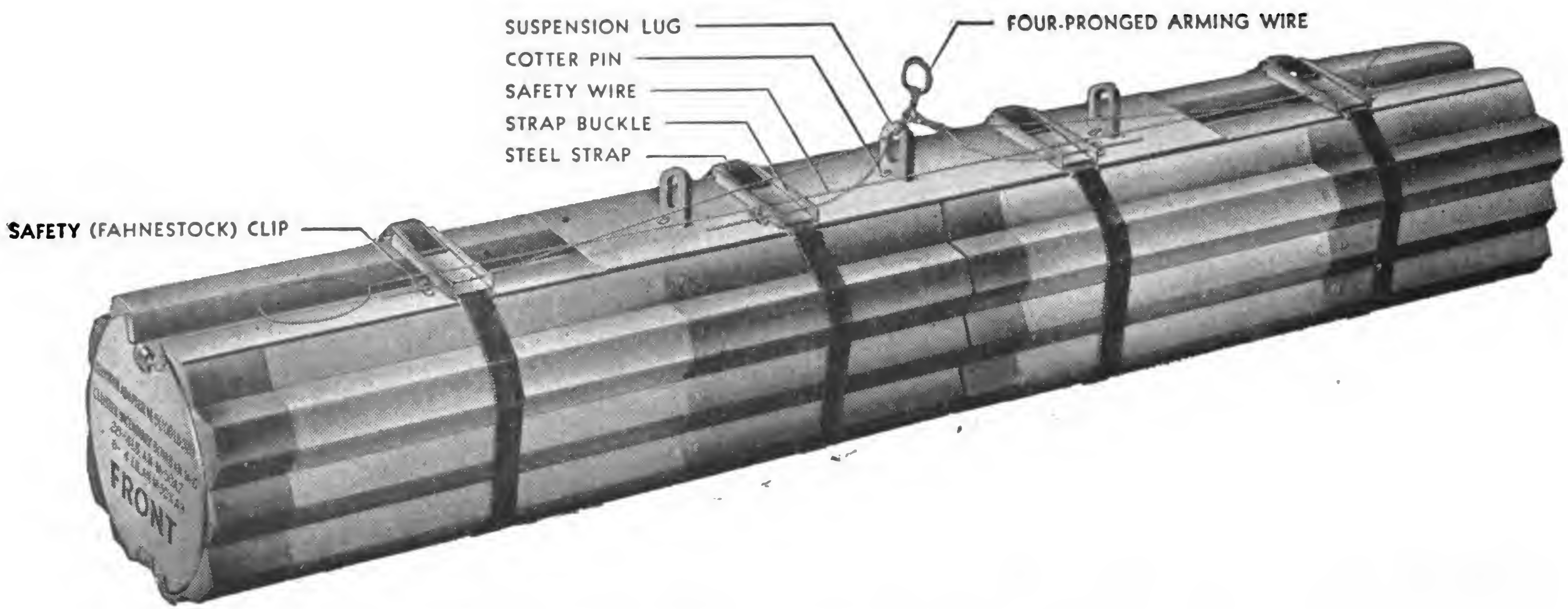


Figure 20.—A cluster of 4-lb. intensive incendiary bombs.

PRACTICE MAKES PERFECT

Hitting a target with a bomb dropped from a fast moving airplane is a tricky operation, and bombardiers need practice like anyone else. The service bombs you have studied so far are not exactly inexpensive, so cheaper bombs are provided for practice use.

One such is the so-called MINIATURE PRACTICE BOMB. This is a small teardrop-shaped slug of cast iron or lead-antimony alloy weighing from 4 to 13 pounds. It has small fins cast into it and is designed to fall in roughly the same path that a full size bomb would follow.

It would be hard to tell from the air whether such a small bomb had hit the target, so SPOTTING CHARGES are used. Into a hole running lengthwise through the center of the bomb is inserted a charge of black powder in a paper cartridge resembling an oversized shotgun shell. A small striker is put in the nose, so that when the bomb hits the ground the striker will set off the spotting charge.

Always remember that, once the spotting charge has been inserted, these innocent looking little slugs of metal are MORE DANGEROUS to handle than any other bomb the Navy uses. Service bombs can be safetied while they are being handled, but these little practice bombs are ALWAYS ARMED. If you drop one from your hand, the spotting charge will probably go off—throwing out a jet of smoke and flame that can burn you seriously or injure the aircraft.

To provide more realistic bombing practice, larger practice bombs are used. These are the size of 100-pound, 500-pound, and 1,000-pound GP bombs. They are sheet metal affairs roughly resembling GP bombs except that the tails are welded on. To give them weight, they are filled either with SAND or WATER. When filled with wet sand, they weigh as much as the

bombs they are intended to resemble. This makes them behave more like service bombs. When filled with water, they weigh about half that. These WATER AND SAND FILLED BOMBS are relatively fragile and must be handled with care. Particular care must be taken not to dent or bend the fins, as bent fins result in an erratic flight path, making the bombs useless for practice.

THE VARIOUS MARKS AND MODS

You are now familiar with all the general types of bombs used by the Navy. Within each type, of course, there are lots of different bombs, each with its MARK and MODIFICATION number, for a total of some 40 or 50 marks and mods.

As you work with bombs, you will encounter three different types of designations, indicating three main classes of bombs—Army bombs, Navy bombs, and Standardized bombs.

Before the war the Army and the Navy each developed its own bombs. Both services used the same general types, but there were marked differences between an Army GP bomb, for instance, and a Navy Demolition bomb.

After the war began, it was decided that it would be more efficient to STANDARDIZE the bombs used by the two services. A standardization committee was set up with representatives from the Army and the Navy. British representatives were also included so that the standardized equipment could be used in British aircraft.

In each type, an Army or Navy bomb was picked. Usually, it was necessary to modify its design slightly so that it could be used by the other service and by the British.

When a bomb had been standardized, the letters AN

(Army-Navy) were placed before its designation. Thus, the AN-M 30 is a 100-pound GP bomb which has been standardized from the Army M 30 bomb. The AN-Mk 1 bomb is a 1600-pound AP bomb standardized from the Navy Mk 1 bomb. In general, standardized depth and armor-piercing bombs are modifications of Navy originals. Most other standardized bombs are modifications of Army originals.

Manufacture of unstandardized Navy bombs was stopped in the middle of 1943. Some of them may still be found at advanced bases and depots, but when the present supply is exhausted, the Navy will use only the standardized bombs.

The same standardization program has been followed on fuzes and some other types of equipment. Army, Navy, and standardized equipment is designated in the same manner as with bombs.

It is easy to tell from the designation with which service a bomb originates, because the Army abbreviates the word "mark" by the letter M, while the Navy abbreviates it as Mk. Thus, a 600-pound Army GP is designated M32, while a 500-pound Navy GP is a Mk 12 Mod 2. The "Mod 2" in the Navy designation means that this bomb is the second MODIFICATION of the Mk 12 model. Modifications of Army equipment are indicated by following a designation with the letter A and a number, as for instance M50 A1.

HANDLES FOR BOMBS

So far as doing damage to the enemy is concerned, a bomb is just a simple steel box full of explosives plus a fuze to set it off. But lots of things have to be done with bombs before you can drop them on the enemy. They have to be picked up, moved around, suspended under the wings of planes, slung into bomb bays, fastened under dive bombers. So you need handles.

The most important bomb handles or attachments are the SUSPENSION LUGS. These are U-shaped steel loops by means of which the bomb is hooked to the racks or shackles of an airplane. These suspension lugs are usually welded to the body of the bomb. On some depth and AP bombs (see fig. 14), they are bolted or screwed to the bomb body.

Bombs are usually suspended from TWO LUGS 14 inches apart, except that 2,000-pound bombs are suspended from lugs 30 inches apart. The British method of suspension involves the use of only one lug, and

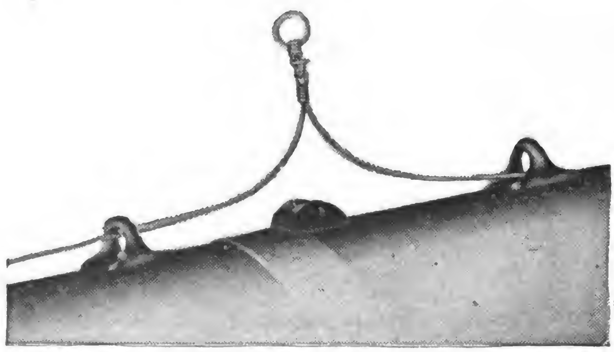


Figure 21.—Welded-on hoisting and suspension lugs of a 500-lb. Navy bomb. The hoisting lug is in the center.

therefore a SINGLE LUG is provided, opposite the double lugs, on AN-standard bombs. You can see this single lug in figure 13.

Large bombs have to be hoisted up under the wings or into the bomb bay of an airplane with a cable and winch. Somehow the cable must be fastened to the bomb, so HOISTING LUGS are provided. On Navy bombs the hoisting lugs are welded or screwed to the bomb case, but on AN-standard bombs of Army origin, the hoisting lugs are fastened to metal bands which can be placed around the bomb when needed and tightened in place with bolts. (Fig. 23.)

When a bomb is suspended under a wing, it is usually drawn up to the rack with a single cable and there-

fore only one hoisting lug, located between the suspension lugs, is needed.

For suspension in a bomb bay, the bomb must be tilted to bring the suspension lugs up to the racks on the side walls of the bomb bay. Therefore, a double hoisting line is usually used, so that the bomb can be tilted by slacking off on one line or the other. This requires two hoisting lugs on either side of the bomb. The Army method of hoisting is to place a canvas sling under the bomb and run one line to each end of the sling. This method is occasionally used by the Navy when loading LAND BASED aircraft. Aboard ship, METAL BANDS are always used to keep the bombs from getting away when the ship rolls.

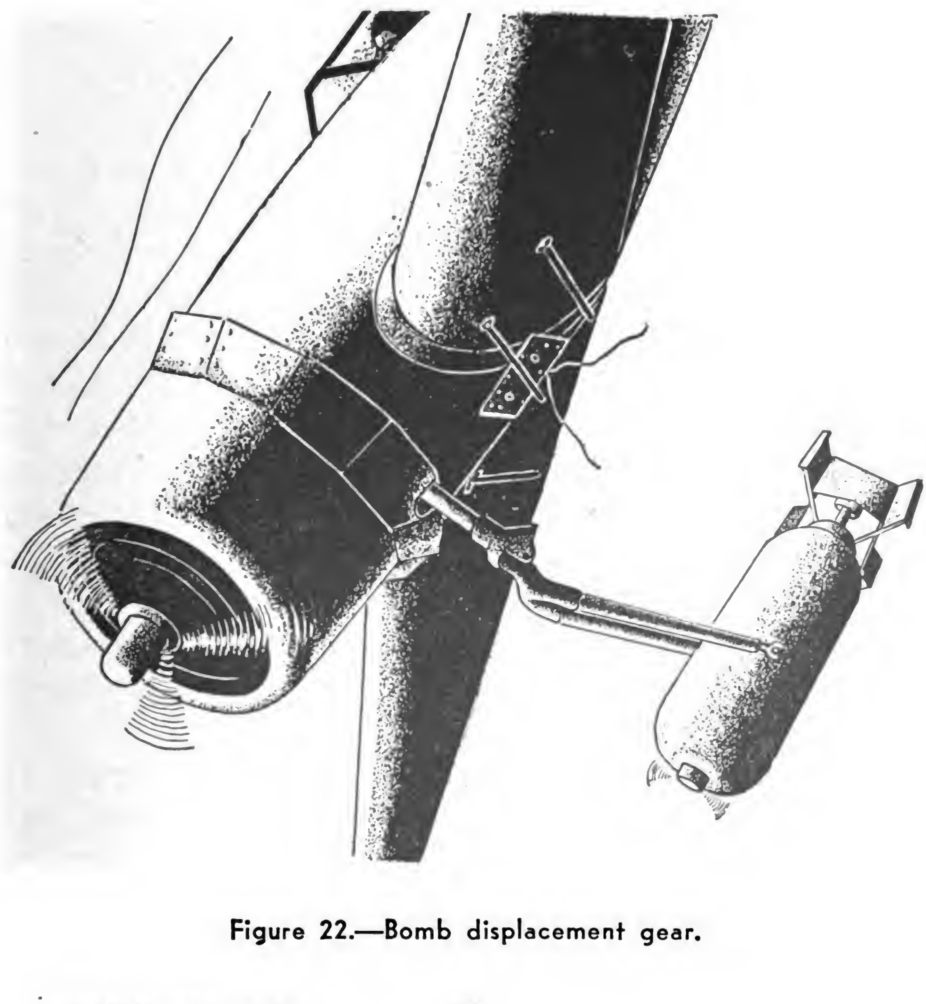


Figure 22.—Bomb displacement gear.

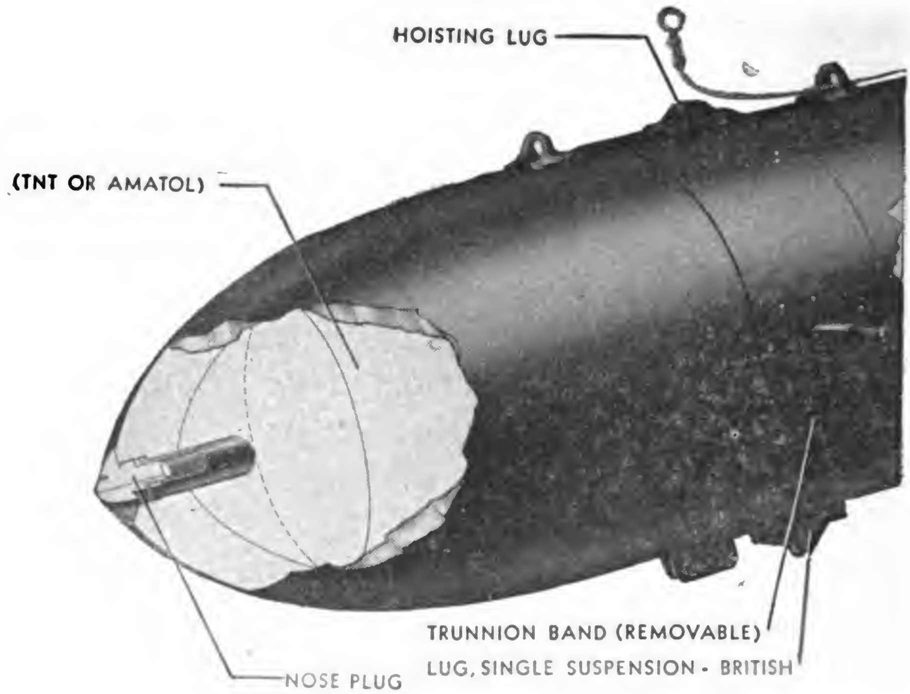


Figure 23.—Hoisting-trunnion band fastened to a SAP bomb.

In a DIVE BOMBING operation, the plane is in a steep dive at the moment when the bomb is released. If the airplane simply let go of the bomb, the bomb would fall forward almost in the line of flight of the airplane and might crash into the prop. Therefore, you have to push the bomb away from the airplane at the same time that it is dropped. DISPLACEMENT GEAR is used for this purpose. (See fig. 22.) This is a horseshoe-shaped rig, pivoted to the forward end of the bomb bay at the rounded part of the horseshoe. The two arms of the displacement gear rest against the bomb. When the bomb is dropped, its weight makes the displacement gear swing around its pivot, thus pushing the bomb away from the plane.

There has to be a projection of some sort on the bomb against which the displacement gear can butt. TRUNNIONS are used for this purpose. As you can see from figure 23, they are simply little shafts stick-

ing out of the side of the bomb. On some of the old Navy bombs, trunnions are welded to the case. On armor-piercing and some depth bombs they are screwed into tapped holes in the case. But on most bombs they are welded to BANDS which are placed around the bomb and tightened with bolts. Frequently, as in the drawing, HOISTING-TRUNNION BANDS are used which carry both a hoisting lug and a pair of trunnions.

CHAPTER 4

BOMB FUZES

WHAT MAKES A BOMB EXPLODE?

You have now seen that a bomb is a container of high explosives with a tail to make it fall smoothly and with various handles—hoisting lugs, suspension lugs, trunnions—for lifting it into and mounting it in aircraft. In addition, a bomb must carry equipment to make it explode—BOOSTERS and FUZES.

The first time that bombs were ever dropped from an airplane on an enemy was in 1907 when the Italians were putting down a tribal revolt in Africa. The bombs used were very simple affairs. They were just tin cans filled with nitro-glycerin. Nitro-glycerin is the "soup" used by safe crackers. Even a slight jar will set it off.

Exploding these primitive bombs was no problem. The SHOCK of hitting the ground set off the nitro-glycerin without further ado. Even today, that is the way the average civilian thinks of a bomb as operating.

You, however, know that a bomb such as the early nitro-glycerin bomb would not be at all practical for modern military use. If anyone shot at the airplane

carrying it and the bullet struck the bomb, that would be the end of the bombing mission. If the ordnancemen let the bomb slip while loading it on the plane, that would be the end of the ordnancemen.

To permit safe and easy handling, therefore, modern bombs use relatively INSENSITIVE explosives such as TNT or amatol that are hard to explode. You can drop a TNT-loaded bomb from 3 miles up in the air onto solid ground. And the TNT will not explode.

That's all very nice and reassuring while you are handling the bomb. But all the same, the bomb does have to explode eventually. How is this done?

The only practical way to set off these explosives is by means of ANOTHER EXPLOSION. Explode a charge inside a block of TNT, and if the charge is big enough the block itself will explode. So somewhere in the bomb there must be some SENSITIVE explosive which can be made to go off easily. But if the bomb is to remain safe to handle, this charge must be a SMALL one.

The sensitive charge, known as a PRIMER, consists of a fraction of an ounce of mercury fulminate or lead azide. These explosives are easy to set off. Hit them with a hammer, push a nail into them, and they will detonate.

But the primer is so small that it makes no more than a little fire-cracker pop when it goes off—nowhere near enough to explode the main charge of the bomb. Before it will do the job, this little explosion has to be AMPLIFIED just as the weak incoming signal on a radio set is amplified so you can hear it. This is accomplished by means of the EXPLOSIVE TRAIN.

First things in the explosive train are the primer and a FIRING PIN. This last is simply a pin—sharp or blunt—which can be driven into the primer to detonate it. Next to the primer (fig. 24) is placed a charge of explosive known as the DETONATOR. The detonator is

composed of an explosive mixture less sensitive than the primer. Because it is less sensitive it can safely be made LARGER than the primer, but it is still small enough and sensitive enough so that the explosion of the primer will set it off.

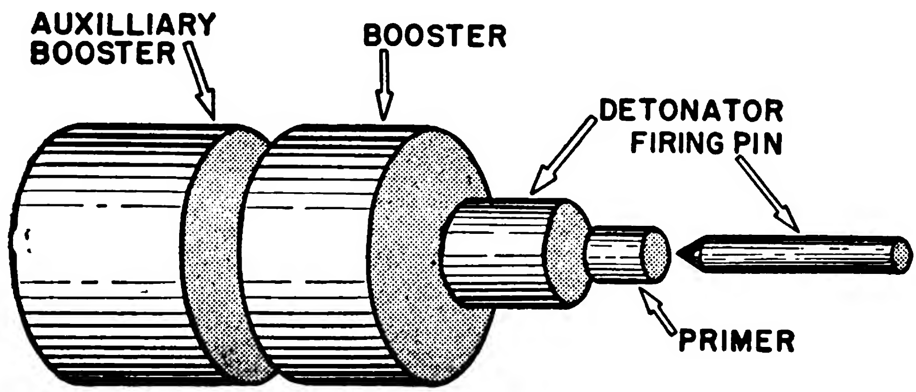


Figure 24.—Elements of an explosive train, ready to fire.

The detonator is still not big enough to explode the main charge. So next to it is placed a larger charge—usually tetryl—called the BOOSTER. Next to the booster is the AUXILIARY BOOSTER, which is usually tetryl or granulated TNT. The explosion of the booster and auxiliary booster is powerful enough to set off the main charge of the bomb.

Thus, to explode the bomb—the firing pin is driven into the primer, the explosion of the primer sets off the detonator, which sets off the booster and auxiliary booster, which in turn detonate the main charge—all in a fraction of a second.

Most bombs used by the Navy have two of these explosive trains to detonate them. Small bombs have only one, and some depth bombs have three. One explosive train would be enough to detonate any bomb, no matter how large, but several are usually provided so that if one fails to work the other can still set off the bomb.

It would be possible to build the whole explosive

train right into the bomb, and this is actually done in some small incendiaries. But bombs can be stored and handled more safely if the sensitive portions of the train—the primer end—are left out of the bombs until they are ready to be used. Therefore, several elements of the sensitive end of the train are usually put in a separate mechanism—the FUZE—which is stored separately from the bomb. Then, just after the bomb is loaded into the aircraft, the fuze is screwed into the fuze recess provided in the bomb.

Most fuzes contain the firing pin, the primer, the detonator, and the first booster. Then the auxiliary booster is mounted in the bomb. In Navy-type bombs the auxiliary booster, designated Mk 1, is a steelcased pellet which will be found in the fuze seat liner. On army and standardized Army bombs, the auxiliary booster is out of sight, buried in the TNT at the time when the bomb is filled.

Exceptions to this rule are the TAIL FUZES of Army and standardized Army bombs. They contain only the firing pin, primer, and detonator. Both the booster and auxiliary booster are built into the bomb. The booster is found in the adapter-booster which is screwed into the base plug (fig. 13). The fuze, in turn, is screwed into the adapter-booster.

With the explosive train thus split into two parts, SAFE STORAGE of bombs and fuzes is quite easy. The bomb is not SENSITIVE enough to be very dangerous by itself, and the fuze alone is not BIG enough to be dangerous. So if they are just kept APART all is well.

BOMBS AND FUZES MUST ALWAYS BE STORED IN SEPARATE MAGAZINES, never together—except for small frag clusters and incendiaries whose fuzes are shipped assembled to the bombs.

The firing pin may be driven into the primer in many ways. By far the commonest method is to use the force of IMPACT with the ground to drive the firing pin. In other cases, however, the firing pin is driven by a spring and is released when the bomb has reached a certain depth of water, when a certain amount of time has passed, when the bomb has fallen a certain distance through the air, or in other ways—depending on the use to which the bomb is to be put.

The impact action is the one with which you will be most often concerned. There are two main types—the NOSE fuze and the TAIL fuze. The nose fuze is fired in a very simple manner. The firing pin projects

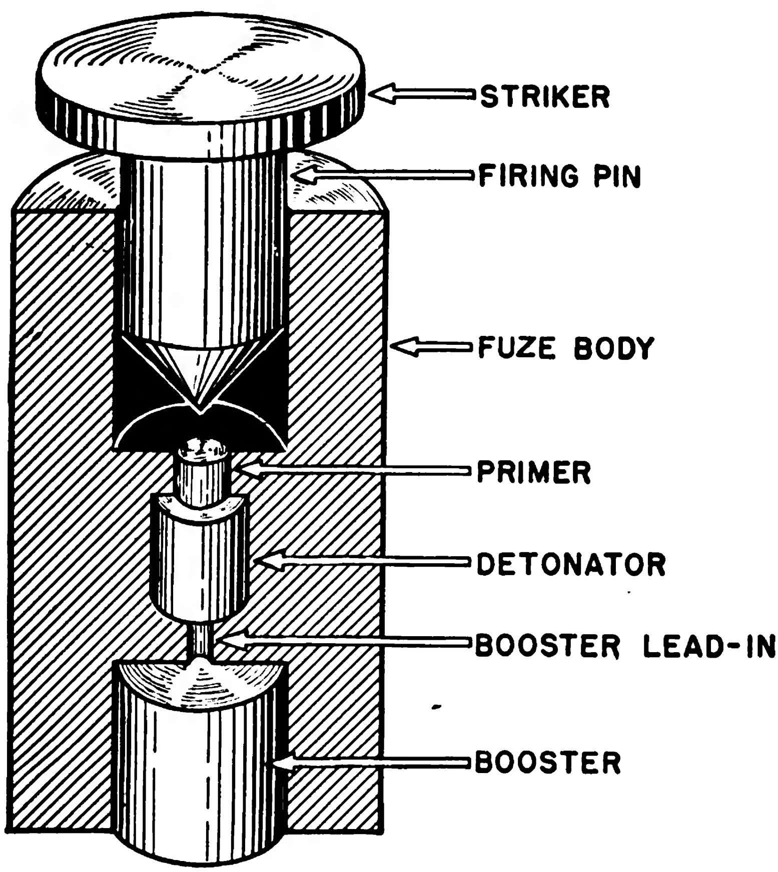


Figure 25.—Elements of a typical nose fuze.

out a short distance in front of the bomb (fig. 25). Just before the bomb touches the ground the firing pin STRIKER hits the ground and is driven into the primer.

This provides a QUICK explosion, because the firing pin is driven into the primer even before the bomb itself touches the ground. Thus even a bomb with a very thin case will explode before it has a chance to break up as a result of ground impact. This type of fuze action is usually described as INSTANTANEOUS.

In a tail fuze, the firing pin is attached to a rather heavy PLUNGER or striker which is held away from the primer by a light spring, known as an ANTI-CREEP SPRING. When the bomb hits the ground, it is SLOWED or stopped. The plunger, however, continues to move on downward, compressing the anti-creep spring, and thus drives the firing pin into the primer. This is a slower action.

Nearly every bomb fuze used in the Navy fires in one of these two ways.

KEEPING FUZES SAFE

You have undoubtedly realized by now, however, that once this sort of mechanism has been mounted on a bomb, the bomb is unsafe to handle. If the protruding firing pin were bumped into something, if the bomb slipped while it was being loaded aboard the plane, it would explode. Somehow the mechanism must be rendered SAFE.

There are two ways in which a mechanism such as this can be safetied.

One way is to PREVENT the firing pin from moving. This might be done by running a bar through it, by putting a block of metal under the striker head or screwing the striker to the fuze body. You can easily think of a multitude of other ways it could be done.

The other way to safety a fuze is to move some part

of the firing train—the pin, the primer, the detonator, the booster—OUT OF LINE with the other elements in the train. This is known as BREAKING THE FIRING TRAIN. Thus in the drawing (fig. 26) the firing pin is free to move but the fuze is safe all the same. Even

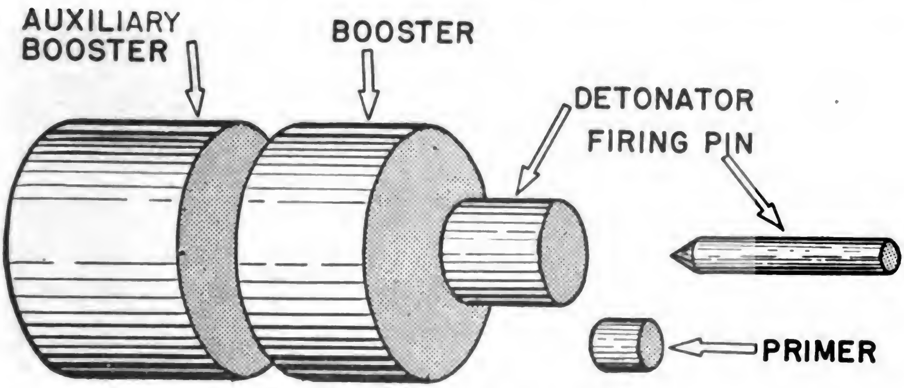


Figure 26.—The firing train is broken.

if the firing pin should be driven in, it cannot hit the primer and therefore will not fire the bomb.

Some of the fuzes employed by the Navy use the first of these two methods, some use the other, and some use both.

HOW A FUZE ARMS

There remains only the problem of unsafetying or ARMING the fuze so that it will fire when it hits the enemy. The ideal way to do this would be to have the fuze arm AFTER it had left the airplane. If this could be done the fuze would be safe all the time it is being brought to, loaded in, and carried in the airplane. But it would be armed when it hit the ground.

To make a fuze arm itself in the air sounds like a tough job. But that is exactly what is done in most fuzes used by the Navy.

Here is how it is done. A little propeller or ARMING VANE is attached to each of the fuzes. As the bomb falls, the rush of air that passes the bomb spins the

arming vane. And the rotation of the arming vanes is used to operate the mechanism which arms the fuze.

There are dozens of ways in which this can be accomplished. One simple way is shown in figure 27, which is a cross-sectional drawing of the AN-M 100 A2 fuze. This is a tail fuze of a type which is used in nearly all standardized Army bombs. You can see in figure 13 what it looks like from the outside.

In the drawing, notice that the FIRING PIN is a little nubbin extending from the base of the PLUNGER. It is located directly above the PRIMER. In the drawing, the fuze is safe, because the ARMING STEM has been screwed through the FUZE BODY and into a threaded hole in the plunger. The plunger is thus locked to the fuze body and cannot move.

As the bomb falls through the air the ARMING VANES rotate and in so doing rotate the arming stem. They do not do this directly because this would arm the fuze TOO FAST. Instead, the arming vane drives the arming stem through a system of REDUCTION GEARS. The gears are so arranged that when the vanes make 23 turns, the arming stem makes one complete turn.

A key attached to the fuze body prevents the plunger from rotating, although the plunger is free to move up and down. Therefore, as the arming stem rotates, it unscrews itself from the hole in the plunger. When the arming stem has completely withdrawn from the plunger, there is nothing preventing the plunger from moving except the ANTI-CREEP spring.

At this point the fuze is ARMED.

Now, when the bomb hits the ground, it will slow up or stop. The plunger, however, will continue to move. It will drive downward, compressing the anti-creep spring, and will drive the firing pin against the primer, thus detonating the bomb.

A somewhat more complicated case is shown in figure 28, a cross-sectional drawing of the AN-M 103

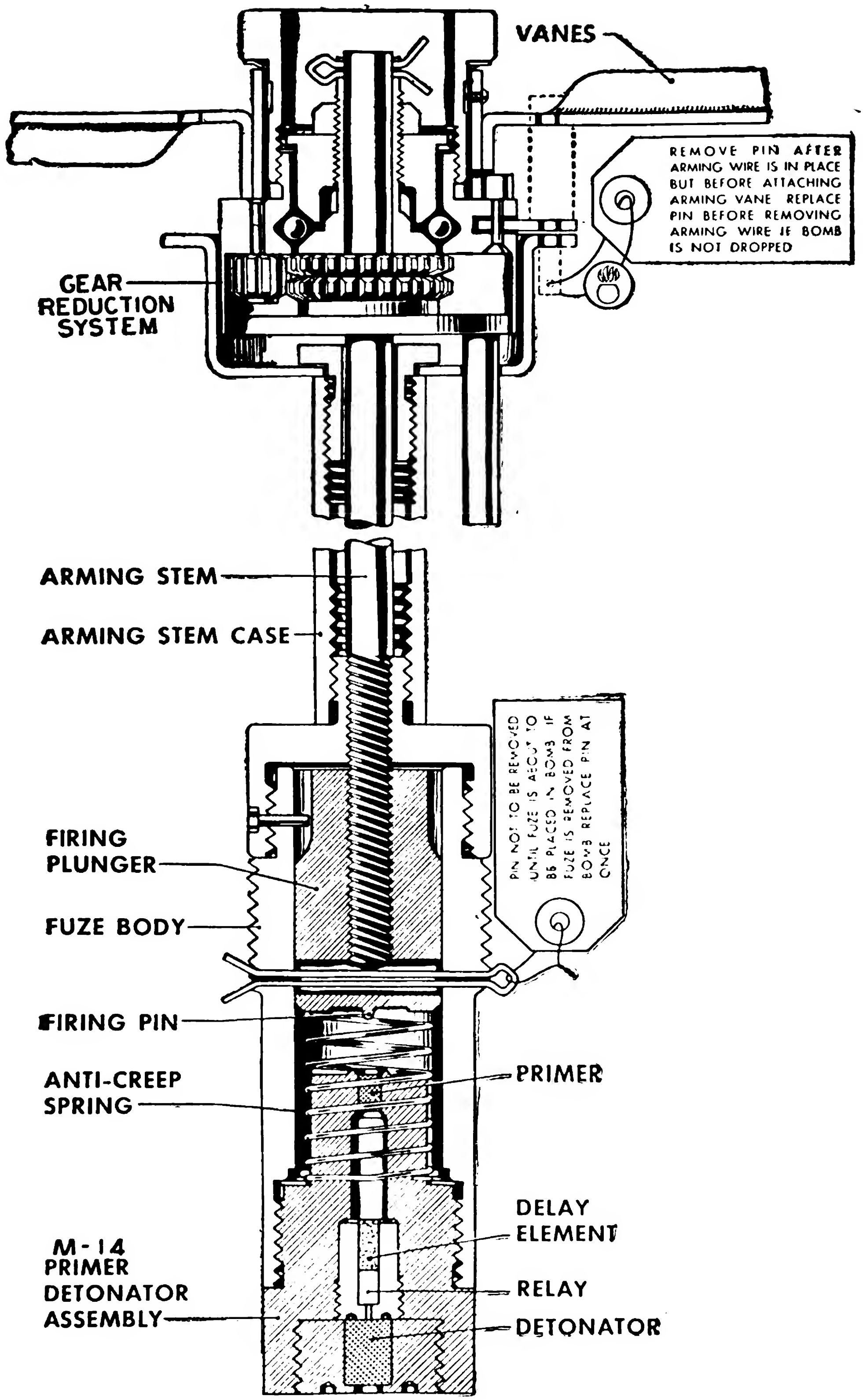


Figure 27.—Mechanism of the AN-M 100 A2 tail fuze, safe condition.

fuze. This is a nose fuze which can be used in nearly all bombs except the incendiary, chemical, and small fragmentation bombs. The same fuze is shown from the outside in figure 13.

This fuze is safetied in two ways. The striker cannot move and the firing train is also broken. The STRIKER, which carries the FIRING PIN, is prevented from moving by the ARMING DISKS which are placed between the striker flange and the FUZE BODY. A leaf spring inside the safety blocks is trying to throw them outward, but they are held in place by the VANE CUP which fits down over them. The vane cup is held in position by the ARMING SCREW, which is screwed into a threaded hole in the center of the striker. The firing train is broken by mounting the primer and the detonator in a SLIDER. In the drawing the slider is off at one side of the fuze, where the primer-detonator is out of line with the firing pin. A spring, which does not show on the drawing, is trying to push the slider back into the lined-up position. But the slider is held in the safe position by the ARMING STEM, a vertical shaft which sticks down into the slider cavity and fouls the slider. A spring is trying to push the arming stem up out of the way of the slider, but the top of the stem butts against the underside of the REDUCTION GEAR ASSEMBLY in the vane cup, so the stem cannot rise.

When the VANES turn, they rotate the arming screw through a reduction gear system which produces one turn of the screw for every 65 turns of the vanes. As the screw rotates, it screws itself up out of the hole in the striker, lifting the vane cup as it rises. Eventually, the vane cup rises far enough so that it no longer holds the arming disks in place, and they are thrown outward by their spring.

The striker is now free to move except for a brass wire, known as the SHEAR PIN, which protrudes from the fuze into a hole in the side of the striker.

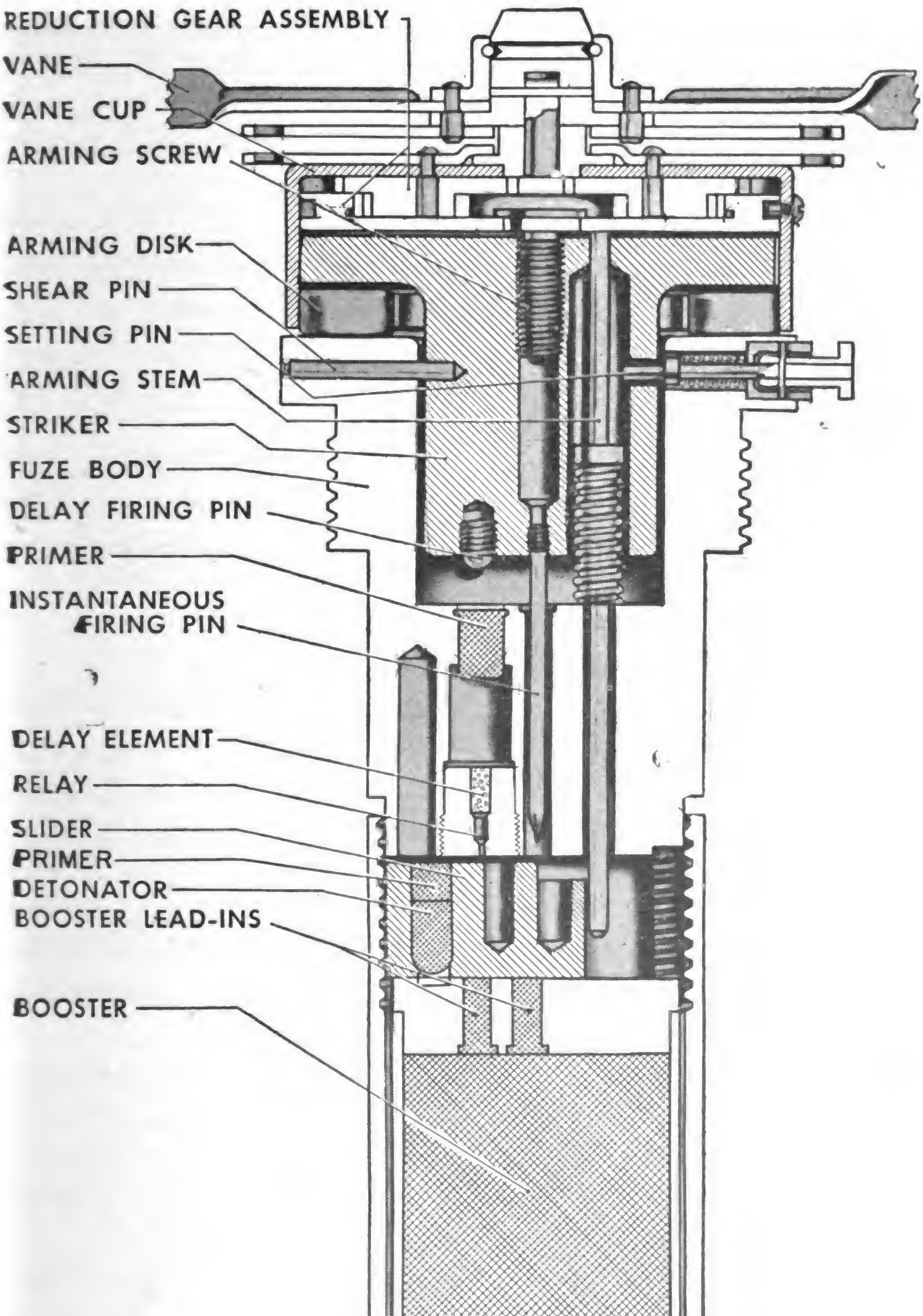


Figure 28.—Mechanism of the AN-M 103 nose fuze. Safe condition.

At the same time, the arming stem, pushed by its spring, follows the vane cup upward. When the arming stem has risen high enough to clear the slider cavity, the slider is pushed toward the center by its spring. This lines up the primer and detonator under the firing pin.

The fuze is now ARMED.

As the vanes continue to turn, the arming screw will screw itself completely out of the hole in the striker, and the vanes, vane cup, gear reduction assembly, and arming screw will fall away, leaving the fuze looking like figure 29.

When the bomb hits, the striker—which sticks out in front of the bomb—is driven inward, breaking the shear wires and forcing the firing pin into the primer. This detonates the bomb.

DELAYS AND FUNCTIONING TIMES

If there were nothing more to a fuze than what you have already learned, a bomb would always explode as soon as it struck the target. But often you don't want this. You want the bomb to penetrate BEFORE it explodes. If a bomb is dropped on a merchant ship, for instance, you don't want it to explode on the deck. You want it to penetrate deep inside the ship, where the explosion will do the most damage.

To accomplish this, a DELAYING ACTION is incorporated into many fuzes. Instead of detonating the bomb as soon as it hits, such a fuze will set off the bomb a fraction of a second after the impact. This is done by putting a DELAY ELEMENT into the firing train.

This delay element (fig. 30) is put next to the primer. It is usually a pellet of tightly packed black powder, which is ignited by the explosion of the primer. Then it takes a definite time—perhaps 0.01 second, perhaps 0.1 second—to burn through.

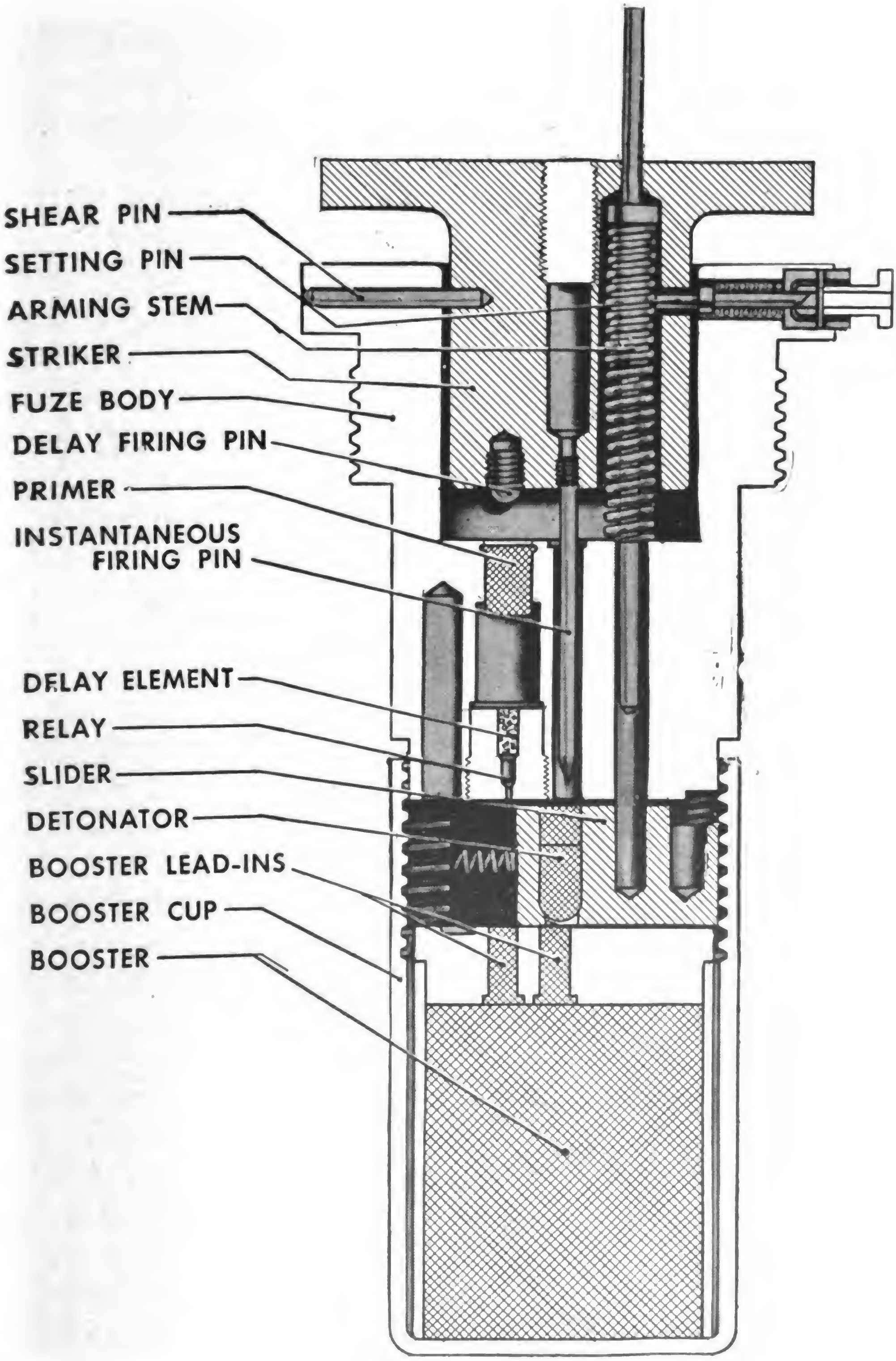


Figure 29.—Position of mechanism when the AN-M 103 fuze is armed.

A second primer, known as the RELAY, is put next to the delay element. When the delay has burned through, the heat of its burning detonates the relay. The relay sets off the detonator. The detonator sets off the booster, which sets off the auxiliary booster—and the bomb explodes.

It might seem offhand as though a delay of 0.01 second wouldn't make much difference one way or the other. But a bomb strikes at a speed of anywhere from 600 to 900 feet per second. In 0.01 second, the

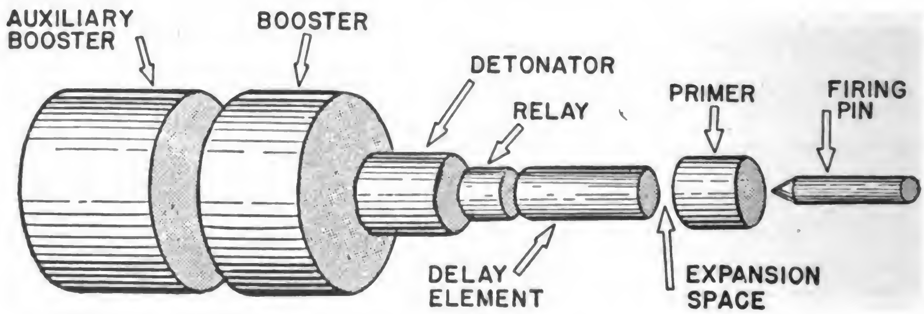


Figure 30.—Elements of a delay train.

bomb will travel 6 feet or more. This is enough to permit penetration through the first deck of a ship before the explosion and will give quite a different effect from an explosion on the top deck.

The amount of delay in the firing of a fuze is known as its FUNCTIONING TIME.

The functioning time of the AN-M 100 A2 fuze described above can be varied. Notice that the primer and detonator are mounted in a separate piece—called the M-14 PRIMER-DET—which is screwed into the base of the fuze. The M-14 primer-det is made with several different delay times. It is made with no delay, which gives a NON-DELAY functioning time, or with delays of 0.01 second, 0.025 second or 0.1 second.

The delay time built into an M-14 primer-det is always stamped on the base of the primer-det. But even those who can't read can tell what the delay time

is, because it is indicated by a color code. Primer-dets with 0.1 second delay have the WHOLE BASE painted black. Those with 0.025 second delay have a pie-shaped section amounting to a QUARTER of a circle painted black. Those with 0.01 second delay have one EIGHTH of a circle painted black, while non-delay primer-dets are UNPAINTED.

To change the delay of the fuze it is only necessary to remove the M-14 primer detonator and screw in another one with the desired delay. When you are doing this, take great care not to drop or strike the primer detonator. It is VERY SENSITIVE and will explode if struck.

The AN-M 103 also has an adjustable delay. It may be set for instantaneous functioning time or for 0.1 second delay. To see how this is accomplished, notice in figure 28 that the striker actually carries TWO firing pins. In addition to the long INSTANTANEOUS firing pin at the center, there is a DELAY firing pin. It is simply a nub located off-center. Immediately below this firing pin is a delay firing train, consisting of a primer, a delay element, and a relay.

When the bomb strikes and the fuze functions, the delay primer is always detonated and ignites the delay element. But if the fuze is set for instantaneous, the bomb will explode long before the delay element has burned through. Even if the bomb did not explode first, the delay element would burn through, would detonate the relay—and then nothing would happen. That's as far as the firing train goes.

But if the slider moved to a position where the primer and detonator were lined up under the delay train, then the explosion of the relay would set off the primer, the detonator, and the booster, and the bomb would explode. The instantaneous firing pin would simply plunge harmlessly into a hole in the slider.

This is just what happens when the fuze is set for

delay. Notice that the slider is built with a STEP at the end facing the arming stem. Suppose the arming stem rises only part way up, so that it does not entirely clear the slider cavity but does clear the first step of the slider. Then the slider will move only part way over, until the cutaway step strikes the arming pin. This will be just far enough to put the primer under the delay train.

To get a delay setting, the SETTING PIN on the side of the fuze is pushed inward so that it extends into the arming stem cavity. When the arming stem rises during the arming of the fuze, the shoulder on the stem will hit the setting pin, and the stem will be unable to rise any further. The slider movement will stop when the primer and detonator are directly under the delay train, and the fuze will be armed for delay action.

WHAT ARMING WIRES ARE FOR

You are probably wondering why the arming vanes of the fuze do not spin and arm the fuze when a bomb is hung under the wing of an airplane. ARMING WIRES are used to prevent this.

An arming wire is a length of brass wire with a flat eyelet at one end. Usually two wires—one for the nose fuze and one for the tail fuze—are attached to the same eyelet. The wires are threaded through the fuzes in such a way that they foul the arming vanes, preventing them from turning (fig. 13). Then the eyelet is attached to a special hook—or RETAINER—on the bomb rack or shackle. This hook is so made that it holds the eyelet very LOOSELY if the bombardier's selector handle is set on "Safe." If the handle is set on "Arm," the hook holds the arming wire FIRMLY. Fahnestock clips are slid over the wire next to the fuze to increase the pull on the retainer.

If the bomb is dropped with the selector set on

"Safe," the loosely-held arming wire will pull away from the hook on the bomb rack and will fall with the bomb. Thus, the arming wire will continue to foul the arming vanes while the bomb is falling, and the vanes will NOT turn. The fuze will NOT arm, and the bomb will strike the ground without detonating.

But if the selector is set on "Arm," the arming wire will be firmly fastened to the bomb rack. When the bomb is released, the wire will be PULLED AWAY from the fuzes. The arming vanes will be free to turn as the bomb falls. They will arm the fuze, and the bomb will detonate upon impact.

Some bomb racks and shackles have several arming wire hooks on them. Thus it is possible to arm one fuze and not the other. This is called SELECTIVE ARMING.

Selective arming is sometimes very useful. For instance, a plane might carry a bomb with the nose fuze set for instantaneous and the tail fuze set for 0.025 second delay. Now suppose the pilot decides to attack an armored warship. His GP bomb cannot get through the armor. In fact, the bomb will break up if it hits armor. But if he can make the bomb explode ON THE DECK it will kill the anti-aircraft gun crews and wreck the anti-aircraft battery.

So he arms BOTH fuzes.

When the bomb hits, the nose fuze will detonate the bomb instantly, before it has a chance to break up on the armor. The tail fuze, of course, will be blown to bits before it does any work, but it might as well be armed as not.

Now suppose the pilot decides to go after an unarmored merchant ship. He wants his bomb to go deep into the ship where it will do the most damage. If the instantaneous nose fuze were armed, the bomb would explode on the top deck before it had a chance to penetrate below decks. So the arming wire running

to the nose fuze is allowed to drop with the bomb. That is, the nose fuze is dropped safe and will not detonate the bomb. The tail fuze is armed. Now the bomb will not explode when it hits the deck but will explode 0.025 second later, when it has had a chance to get down inside the ship.

MORE MARKS AND MODS

A score or more of different bomb fuzes are used by the Navy. It is not necessary as yet for you to know all of them. But there are several with which you should be familiar.

The AN-M 103 NOSE FUZE, already described, is one of the most important. As you know, it is vane arming and has a functioning time of instantaneous or 0.1 second delay, depending on the adjustment of the setting pin. It is regularly used in the nose of all AN-STANDARD GP bombs. It can be used in the nose of all Navy GP bombs except the 100-pound size. It is used in the LARGER frag bombs. It can be used in the nose of all DEPTH bombs. However, when it is used in flat-nosed depth bombs a special set of oversize arming vanes must be used.

The TAIL FUZES used in AN-Standard GP bombs are the AN-M 100 A2, described above, the AN-M 101 A2, and the AN-M 102 A2. These three fuzes are identical except for the length of the STEM CASE. The middle-sized fuze, the AN-M 101 A2, is used on 500-pound bombs. The smaller AN-M 100 A2 is used on bombs under 500 pounds, and the larger AN-M 102 A2 is used on bombs over 500 pounds. These fuzes are also used on the SAP bomb and on the largest fragmentation bomb, the 260-pounder.

The fuzes usually used in Navy GP bombs over 100 pounds are the Mk 221 and the Mk 223. (Fig. 31). The first is a nose fuze and the second a tail fuze.

Both of them are vane arming and have a FUNCTIONING TIME of 0.01 second. As you can tell from the designation, these are Navy fuzes. They are not used anywhere except in Navy GP bombs.

The AN-Mk 219 nose fuze is similar to the Mk 221

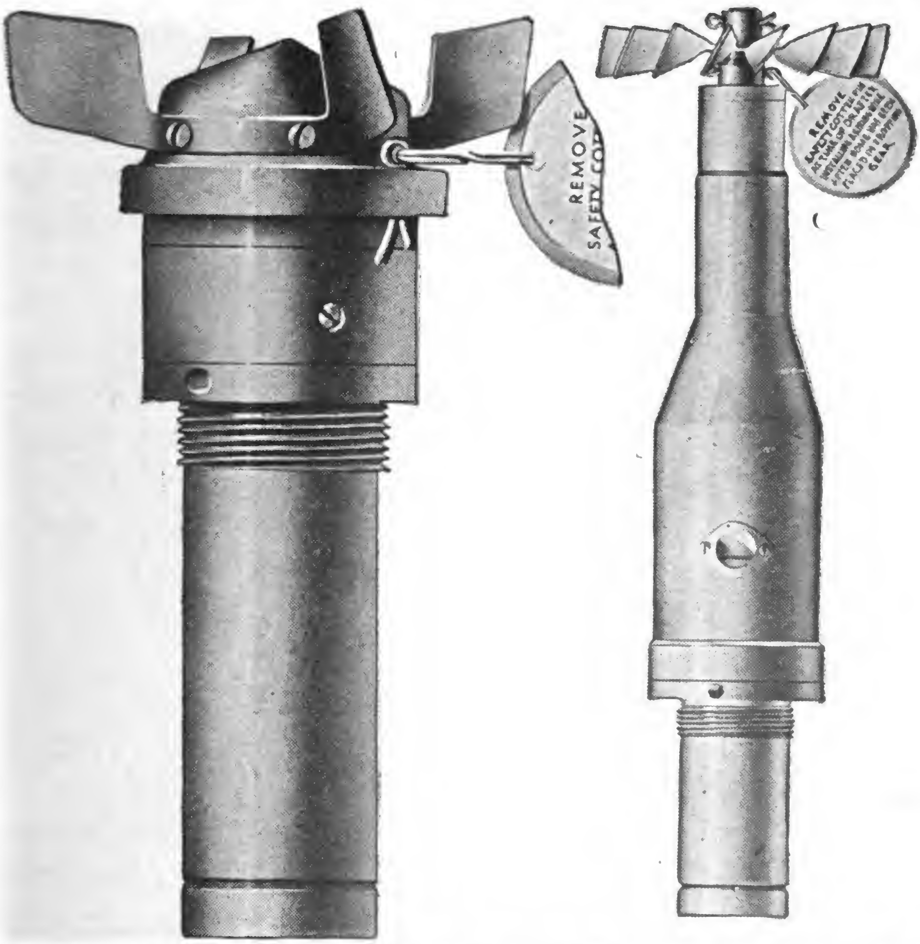


Figure 31.—Navy nose and tail fuzes. The Mk 221 nose fuze is on the left, the Mk 223 tail fuze on the right.

except that it is smaller and has an INSTANTANEOUS functioning time. A Navy fuze, the AN-Mk 219 is used in Navy GP bombs when instantaneous functioning is desired and in the nose of depth bombs. Depth bombs, as you know, must always have an instantaneous fuze when dropped on a hard surface because their light cases would break up if there were any delay in the fuze. When a depth bomb is being dropped on a

submerged submarine, so that it is intended to explode under water, the nose-impact fuze is dropped safe or omitted altogether.

The AN-Mk 219, fits directly into the fuze pocket of the 100-pound Navy GP bomb. It is TOO SMALL to fit any other bomb, and therefore a special ADAPTER RING must be placed over it before it can be used. You can see this arrangement in the nose of the depth bomb in figure 17. Also, you have to insert an extra Mk 1 AUXILIARY BOOSTER into the fuze pocket before putting in the AN-Mk 219. This Mk 1 booster is a 3 inch long steel-cased cylinder of granulated TNT.

The AN-Mk 228 fuze is used in the TAIL of ARMOR-PIERCING bombs. It is vane arming and has a long functioning time of 0.08 seconds to permit DEEP penetration. It is not used in any other bombs. AP bombs, of course, take NO nose fuze. Externally, the AN-Mk 228 looks just like the Mk 223 tail fuze except that it has RED VANES to distinguish it.

FUZES FOR DEPTH BOMBS

All of the above fuzes are impact fuzes. That is, they are designed to detonate the bomb when the bomb strikes. For bombing operations against submerged SUBMARINES, a different type of fuze is required. There is very little chance of actually hitting the submarine. What is needed is a fuze which will detonate the bomb when it reaches a DEPTH OF WATER equal to the estimated depth of the submarine.

For this purpose HYDROSTATIC fuzes are used. In these fuzes, water is admitted into the fuze, where it pushes against a PISTON. Motion of the piston is resisted by a SPRING. The greater the depth of water, the greater the pressure against the piston and the farther the piston will move. When the piston has moved a certain distance, it trips a cocked spring-

loaded firing pin, which strikes the primer and detonates the bomb.

The depth at which a hydrostatic fuze fires may be set for 25, 50, 75, 100, or 125 feet. On the newer hydrostatic fuzes, the depth is set by moving a dial on the outside of the fuze. Older fuzes must be taken apart to make the setting. The most commonly used setting is 25 feet.

There are two types of hydrostatic fuses—tail fuzes and athwartship fuzes (fig. 32). Their method of operation is substantially the same, but they are in-

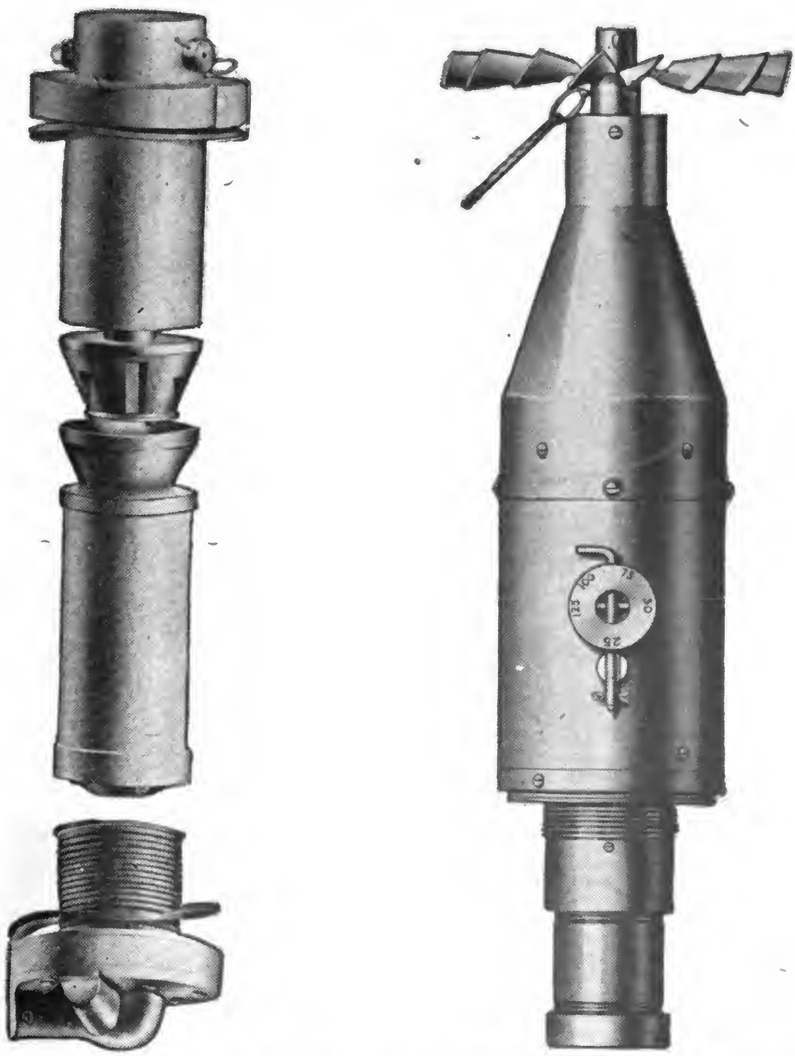


Figure 32.—Hydrostatic fuzes. The one on the left is the AN-Mk 234 athwartship fuze. On the right is the AN-Mk 230 tail fuze.

stalled in the bomb quite differently. The AN-Mk 230, the most commonly used tail hydrostatic fuze is vane arming. The atwartship fuze, AN-Mk 234, is safetied by a pin which is springloaded outward but held in place by the arming wire. When the wire is pulled, the pin jumps out, and the fuze is immediately armed.

HOW TO FUZE A BOMB

Except for a very few of the small types, bombs are always shipped and stored WITHOUT fuzes. The fuzes are shipped separately in sealed metal containers. Fuzes are usually installed in the bomb after it is loaded into the airplane.

To fuze a group of bombs, first assemble the CORRECT number of the proper fuzes, in their containers.

Next, remove the TRANSPORTATION PLUGS from the fuze pockets of the FIRST bomb to be fuzed. If it is a Navy bomb—including all depth and AP bombs—a Mk 1 auxiliary booster will be found loose in the fuze pocket. BE CAREFUL THAT IT DOES NOT DROP OUT. If if is missing, obtain another Mk 1 booster to replace it.

INSPECT the threads of the fuze pocket carefully to be sure that no dirt or exudate has collected there. Exudate, as you know, is a brown gummy substance which is sometimes given off by TNT. It is explosive and must be removed carefully. If dirt or exudate are present, wrap a cloth around a stick and swab out the fuze pocket. NEVER USE METAL TOOLS TO CLEAN A FUZE POCKET.

Now remove the fuzes from their containers. They will have no vanes on them. Arming vanes are shipped separately. The arming vanes of some fuzes snap on, others are fastened with a nut, others with a cotter pin. Exceptions are the Navy nose fuzes—MK 221 and AN-Mk 219—which come with vanes attached.

Standardized Army fuzes always contain two or

more pairs of eyelets through which an arming wire can be threaded to prevent rotation of the arming vane. When the fuze is unpacked, a COTTER PIN will be found run through one of these pairs of eyelets to prevent rotation. A short loop of wire will be found through another, fastened with a lead seal, known as a CAR SEAL. If the car seal or wire has been tampered with, turn the fuze over to an officer for inspection.

READ CAREFULLY ALL TAGS ATTACHED TO THE FUZE AND COMPLY WITH THE INSTRUCTIONS WRITTEN ON THEM.

Now cut and remove the car seal wire, leaving the cotter pin IN PLACE, and screw the fuze into the fuze pocket. Tighten it up snugly with your hand. AN fuzes of Army origin are usually tightened hand tight only.

Next run an ARMING WIRE through the suspension lugs of the bomb, placing it so that the eyelet of the arming wire is about midway between the suspension lugs. Thread the free end of the arming wire through the NEAREST pair of eyelets on the fuze. If the nearest pair is occupied by the cotter pin, shift the cotter pin to another pair. The cotter pin should always be left on the fuze until the bomb has been installed in the airplane.

Attach the arming vanes. After the bomb has been secured to the bomb rack or shackle, attach the arming wire eyelet to the arming wire hook on the rack, draw the arming wire out straight and cut it off about 3 inches beyond the fuze. Use emery paper or fine sandpaper to remove any burring of the ends of the arming wire. Then slip two fahnestock clips over the end of the wire, bringing them up snugly against the fuze.

Navy NOSE fuzes are installed in almost exactly the same way except that no car seal will be found on the fuze. Also, the fuze should be brought up tight with a small spanner wrench.

Navy TAIL fuzes are also tightened with a spanner wrench. The arming wire is fastened to Navy tail fuzes in a different manner. Welded to the inside of the tail of Navy bombs is an ARMING WIRE BRACKET (fig. 33). After the fuze has been screwed into the bomb, the arming vane is attached to the fuze so that it rotates between the arms of the bracket. The arming wire is then threaded through holes in the two

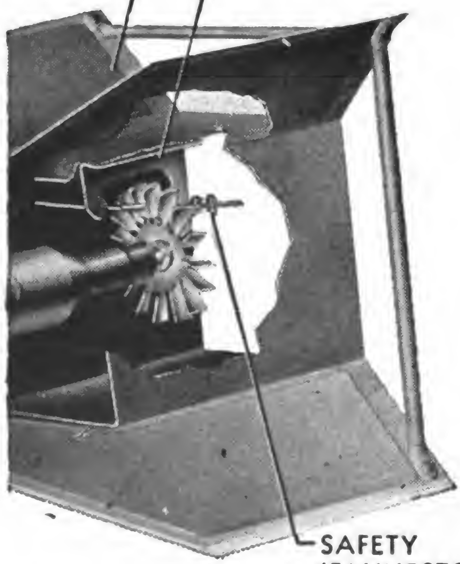


Figure 33.—Arming wire bracket inside tail of a Navy bomb.

arms of the bracket so that it runs between two blades of the vanes.

If the bomb is to be suspended outside the airplane, an arming wire guard—a short length of copper tubing —must be slipped over the arming wire between the arms of the bracket. You can see the tube in figure 33.

Depth bombs and armor-piercing bombs have no arming wire brackets on their tails. Therefore, an arming wire BRACKET ADAPTER (fig. 34) must be

attached to the fuze. Then the arming wire is threaded through the adapter in the same manner as through a bracket.

TAIL HYDROSTATIC fuzes are installed on bombs in the same manner as Navy tail impact fuzes.

Installation of ATHWARTSHIPS hydrostatic fuzes is quite different, however.

Athwartship fuzes come in three parts—the PISTOL

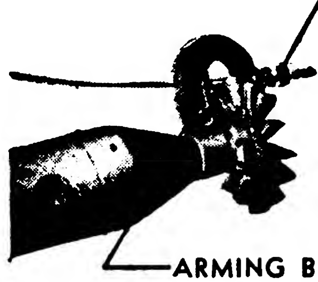


Figure 34.—Bracket adapter attached to AN-Mk 230 tail fuze.

END, which contains the firing pin, primer, and detonator—the BOOSTER—and the BOOSTER EXTENDER, which lines up the explosive train of the fuze when the bomb reaches a depth of 10 or 15 feet of water. The booster is fastened to the booster extender by a bayonet lock.

When the fuze is to be used in large depth bombs, a SPACER must be inserted between the booster and the booster extender. A spacer of the proper size will be found attached to the inside of the transportation plug on these bombs.

Remove the transportation plugs from the two ends of the athwartships pocket and INSPECT the pocket for dirt and exudate. Insert the pistol end of the fuze into one end of the fuze pocket, being sure that the GASKET which you find on the fuze is installed between the fuze and the bomb body. It is fastened by six bolts. Bring ALL the bolts up finger tight. Now tighten the bolts with a wrench, but do this very evenly as if you were tightening up the head bolts on an engine. Tight-

en ONE bolt medium tight. Then tighten the OPPOSITE bolt—and proceed back and forth around the fuze in this manner. Then go around again bringing the bolts up solid.

Now insert the booster and booster extender from the other side of the fuze pocket in the same manner.

Two arming wires are used on these athwartships fuzes, running down the sides of the bomb to the pistol and to the booster extender. The arming wire to the pistol end is threaded through a hole in the depth-setting pin—or, in older fuzes, through a jump-out pin. Cut off the wire about 6 inches past the pin and bend back 3 inches of the wire. A fahnestock clip is not used.

At the booster extender end, thread the wire through the jump-out pin, cut it off beyond the pin, removing any burring and use two fahnestock clips.

HOW TO TAKE CARE OF BOMBS AND FUZES

The proper care of bombs and fuzes is a very simple but very important thing. Like babies, it is mostly a matter of keeping them clean and dry, of keeping them reasonably cool, and of not handling them too roughly.

It is pretty hard, as you know, to make a bomb explode, and there is no need to be afraid of bombs. All the same, DON'T TAKE CHANCES. Don't throw them around. If you want to get a bomb from a truck to the ground, lower it—don't drop it. When moving bombs, be sure that the bomb is carefully attached to the trailer, bomb truck or skid. A very nasty accident, in which a lot of people were killed, occurred at a Naval air base recently because a depth bomb got to dragging on the ground behind a bomb trailer. Friction wore away the case of the bomb and ignited the TPX filler, which then exploded and set off the other bombs on the trailer.

Keep bombs away from HEAT and keep them out of direct sunlight. Store them under a ROOF or a TARPAULIN.

Remember that bomb cases can be dented by rough handling and can rust if they are exposed to moisture and dirt. Even at an advanced base, don't store bombs on the bare ground. Put DUNNAGE under them.

Bombs should always be stored in a properly designated magazine area which conforms to Bureau of Ordnance quantity-distance tables. These tables tell you how far from other structures the magazine must be if it contains a certain quantity of explosive material.

Fuzes must NEVER be stored in a bomb magazine unless the fuze is shipped assembled in a bomb cluster. They should be kept in separate fuze lockers well separated from other explosive material. This is because fuzes contain the most sensitive and dangerous explosives. If they should go up, you don't want other more powerful explosives in the neighborhood to be set off by the explosion.

An exception to this rule is the READY MAGAZINE. Under certain conditions, it is permissible to store bombs and fuzes together in advance of use. In this case, they should be properly guarded against unauthorized people.

Standardized Army fuzes are built so that they require no maintenance. NEVER attempt to disassemble or clean a standardized Army fuze. When these fuzes have been exposed to weather or salt spray about two weeks, they should be removed from the bomb, returned to a depot or thrown overboard in deep water, and REPLACED by fresh fuzes.

Navy-type fuzes, on the other hand, do require maintenance. After EACH exposure to weather, they should be checked, cleaned, and lightly oiled. But this is a

DELICATE job which should ONLY be done by ordnancemen thoroughly familiar with the fuzes.

If experienced ordnancemen are not available, it is better to discard the fuzes. It is never advisable to start on a bombing mission with fuzes which have been checked by inexperienced men.

A HORRIBLE EXAMPLE

A bomb accident in which 20 or more men were killed illustrates almost perfectly how not to handle bombs. At one Pacific advanced base, bombs were habitually fuzed long in advance of use, and allowed to lie around all over the place. Among other places, they lay around on a hillside which was also used as a movie theatre. In the evening, the men found the bombs made handy seats from which to watch the movie. Naturally, some of the arming wires got kicked loose and some of the fuzes became armed.

One evening during the movie, an Ordnanceman noticed that a 100-pound bomb on which his neighbor was sitting had become armed. He yelled, "Look out, that fuze is armed." The neighbor, doubtless feeling heroic, stood up, picked up the bomb, and threw it down the hillside!

The bomb exploded at the foot of the hill. The blast and fragments swept up the slope, practically wiping out the entire movie audience.

In this true story, notice the BLUNDERS which produced the disaster. The bomb should not have been fuzed in the first place. It should not have been allowed to lie around but should have been segregated in a properly guarded magazine. And finally, the Ordnanceman should have known that an armed fuze is dangerous but is not going to explode in the next instant—and that the worst possible thing to do with an armed bomb is to move it.

IN CONCLUSION

As you handle bombs and fuzes remember that if they are treated right they make one of the deadliest weapons in your Navy's arsenal. But if they are treated wrong they kill you and your friends instead of your enemy. Many American sailors have been killed in accidents resulting from mishandling a bomb. And, almost as bad, plenty of Germans and Japs who should be dead today are still fighting because a fouled-up bomb or fuze didn't go off.

The success of a bombing mission depends upon a lot of things—on the skill of the pilot in getting to the target, on the skill of the gunner in fighting off the enemy interceptors, on the skill of the bombardier in hitting his target. But when the payoff comes, when the bomb hits, it all depends on the ordnancemen who finned, fuzed, and loaded that bomb.

CHAPTER 5

TORPEDOES

THE LITTLE SUBMARINE

Suppose you had a small submarine that could travel under the water at the speed of a fast motor boat. Suppose you loaded the front end of the submarine with several hundred pounds of explosives. Then suppose there were a little man inside to STEER this submarine so that it would crash into an enemy ship and the explosive charge would detonate. Now suppose you could carry this submarine in an airplane and drop it close to the enemy.

Be a pretty effective weapon, wouldn't it?

That's what a TORPEDO is, except that there isn't any little man in it. Instead there are special mechanisms inside to steer the torpedo in a straight line and to hold it at a certain depth under the water. It is a self-propelled, self-directed missile, loaded with explosive, which can run under water at speeds up to 33 knots for a distance of several miles.

A torpedo, you can see, is no mere bomb or projectile. Into its 13 feet of length and ton of weight are

packed all the equipment of a fast self-propelled vessel. It's as complicated as, say, a good automobile—but it is made much more carefully and is more expensive.

It takes specially trained and rated torpedomen to service torpedoes. But as an Aviation Ordnanceman, you need some basic acquaintance with torpedoes. You

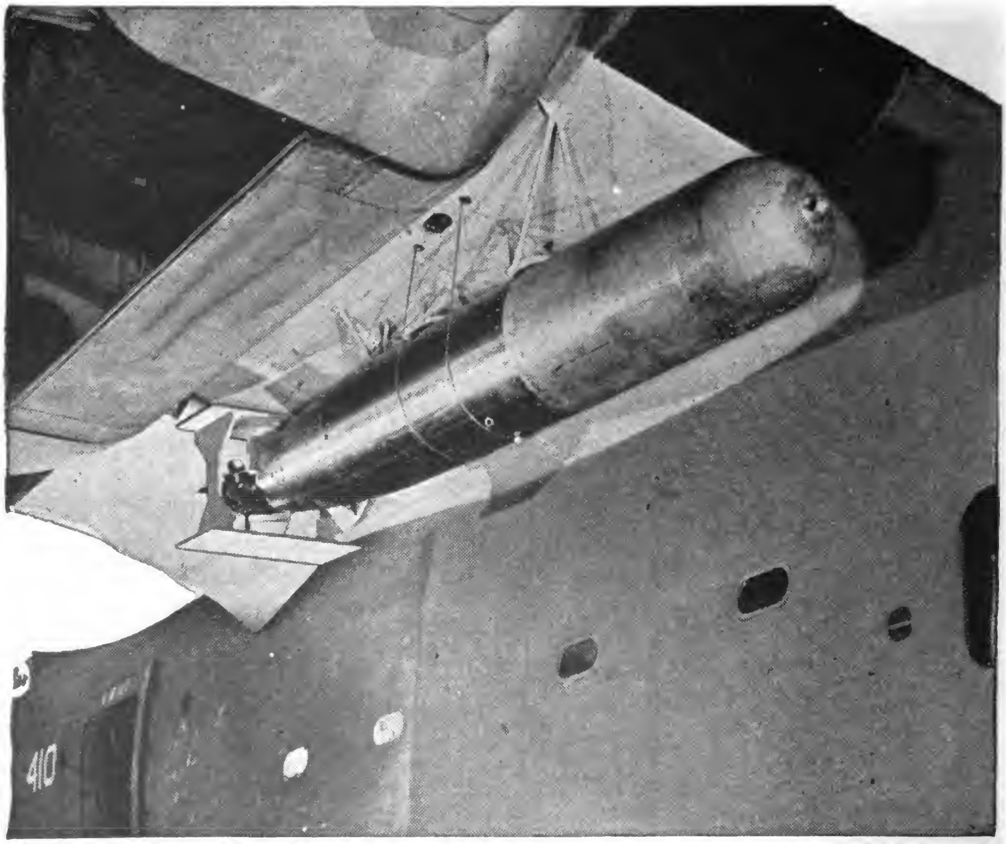


Figure 35.—Aircraft torpedo suspended in a PBM-3. The supporting cables run to racks inside the wing.

will sometimes be required to load them into planes and make last minute adjustments. In emergencies, you may even have to take over some of the servicing work on aircraft torpedoes. You ought to know in general what makes them tick and how to get them into a plane ready to run.

Torpedoes are launched from submarines, from all

sorts of surface warships, from PT boats and from airplanes. You are concerned with the aircraft torpedo. The Mark 13 type is the present model. But the fundamental principles are the same for all of the more common torpedoes. The U. S. Navy AIRCRAFT torpedo is somewhat smaller, shorter and fatter, and is more strongly built to withstand the shock of being dropped

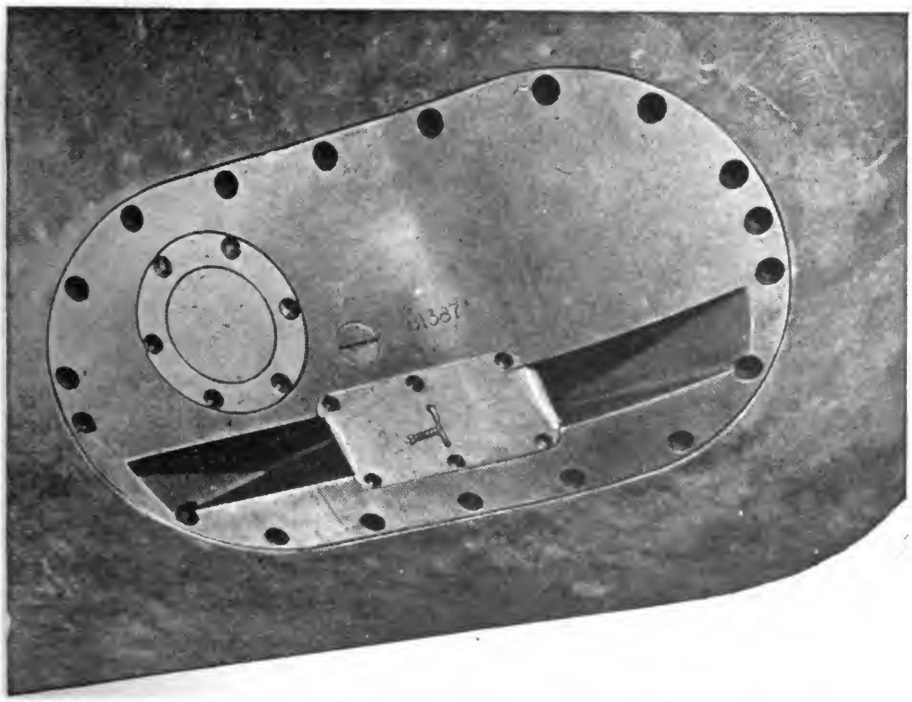


Figure 36.—Exploder mechanism for an aerial torpedo, safetied.

from a speeding airplane several hundred feet in the air.

The aircraft torpedo is cigar shaped, with a rounded nose and a tapering tail. At the rear are horizontal and vertical tail vanes, to which horizontal and vertical steering rudders are attached. Behind the vanes are two four-bladed propellers. Rotating in opposite directions, these drive the torpedo through the water. Ready for a war shot, the torpedo weighs 2,127 pounds, is 13 feet 5 inches long and 22.42 inches in diameter.

The business end of the torpedo is a detachable nose section known as the WARHEAD. In the latest aircraft torpedo the warhead contains 600 pounds of TPX. This huge charge exploding next to the hull below the armor belt can crumple the plates of any ship afloat.

The warhead charge is set off on impact with the target by an EXPLODER mechanism. (Fig. 36.) Though a little more complicated, this is essentially the same thing as the bomb fuzes which you encountered in chapter 3. It has to be somewhat more sensitive than a bomb fuze because the torpedo is traveling slower than a falling bomb and does not hit as hard.

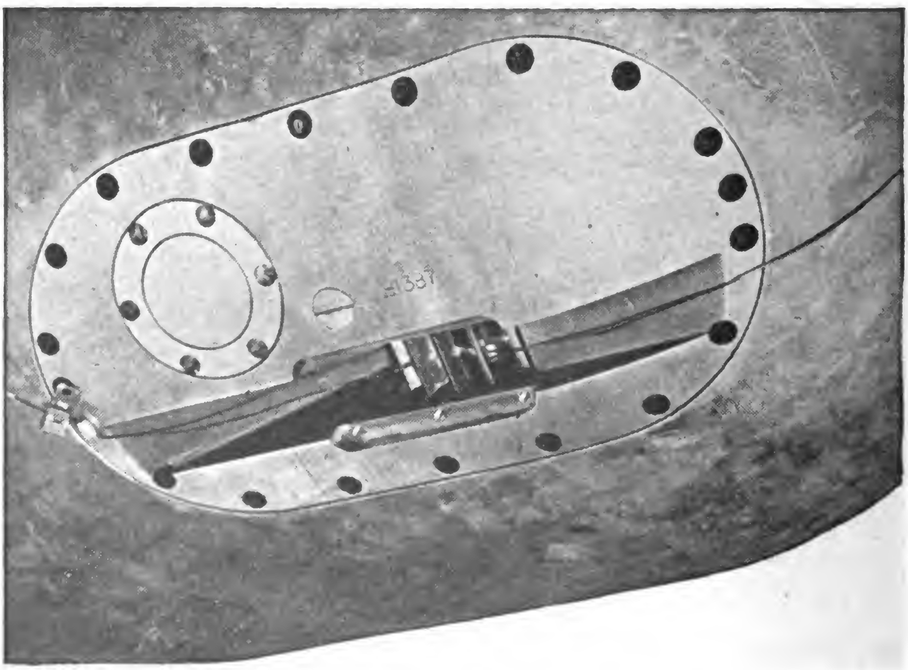


Figure 37.—Exploder with cover plate removed to show the impeller blades. Here the old system of using a bomb arming wire to safety the exploder is shown. You may still encounter it in some places.

Like a bomb fuze, the exploder is in a safe or unarmed condition while it is being handled and carried in the plane. After it gets in the water it is armed by the rotation of a little paddle wheel or IMPELLER mounted at the side of the torpedo where the water can

spin it as the torpedo travels forward. Rotation of the impeller is prevented, while the torpedo is hung in the plane, by thin copper wire which is cut by the impeller blades when the water starts pushing them. The wire is strong enough to resist wind pressure on the impellers.

For practice shots with the torpedo, the warhead is removed and an exercise head substituted. This head does not contain an explosive but is filled with water. At the end of the torpedo's run the water in the exercise head is blown out by compressed air. This makes the head light, and the torpedo floats to the surface, where it can be recovered.

WHAT MAKES THE TORPEDO RUN?

The torpedo is driven through the water by a combination of compressed air, steam, and burning alcohol. COMPRESSED AIR is stored at 2,800 pounds per square inch pressure in a tank known as the AIR FLASK, which takes up about a third of the length of the torpedo. This pressure is too high for a working pressure, so the air is bled off through a PRESSURE-REDUCING VALVE which draws out only enough air to maintain a pressure of about 450 pounds per square inch.

The air line from the air flask to the reducing valve is interrupted by two valves. One, the STOP VALVE, is opened or shut from outside the torpedo with a wrench. This valve is kept closed until just before the torpedo is hung in the plane. A second valve, known as the STARTING VALVE, stays closed at all times until after the torpedo has been dropped, when it is opened automatically.

From the reducing valve, air is led to a COMBUSTION FLASK. ALCOHOL is forced into this flask and burned, raising the temperature of the air to nearly 1,500° F. This causes the air to EXPAND greatly, in-

creasing its volume and thus economizing on the use of the compressed air in the air flask. At the same time, FRESH WATER from a water compartment in the torpedo is injected into the combustion flask in order to keep the temperature from going too high. This water is immediately converted into steam and adds still further to the volume of the gases.

The heated gases are then shot through a NOZZLE onto a TURBINE, causing the turbine to spin. The exhaust from this turbine is led to a second-stage turbine which is spun in the opposite direction. Each of these turbines drives one of the two propellers. The two propellers revolve in opposite directions driven by concentric shafts mounted one inside the other.

It would be possible for the torpedo to operate on air pressure alone, without burning the alcohol. This is known as a COLD RUN. However, without the expansion of the air caused by the alcohol flame, the air would be used up at a much faster rate, and the torpedo would not have as great a range or speed.

ON THE STRAIGHT AND NARROW

You have now seen how the torpedo is driven forward and how it explodes when it hits the target. It remains to be seen how the torpedo is kept headed in the way it should go. Two things have to be done. The torpedo must be kept traveling in a straight line. And it must travel at the proper depth.

The correct DEPTH depends on the target. Against a small, shallow draft vessel, the torpedo must travel fairly close to the surface. Against a large vessel which sits deep in the water, the torpedo may travel 20 feet or so below the water level.

To keep the torpedo on its course and to control its depth, two delicate and complex mechanisms are installed in the torpedo.

The DEPTH CONTROL MECHANISM operates the control valves of a small air motor, known as the DEPTH ENGINE. The depth engine moves the horizontal rudders up or down according to the way its valves are set. The depth control has two devices to operate these valves—a hydrostatic diaphragm and a pendulum.

The HYDROSTATIC DIAPHRAGM is a flexible sheet with an air chamber on one side of it and space on the other side into which sea water is admitted. PRESSURE of the sea water tends to push the diaphragm toward the air chamber, but a SPRING is arranged so that it tends to pull the diaphragm in the opposite direction.

When the torpedo is close to the surface of the water, the spring will pull the diaphragm AWAY from the chamber. When it is deep in the water, the water pressure will be stronger and will push the diaphragm TOWARD the chamber. The diaphragm is connected by levers to the valves of the depth engine. When it is pushed toward the air chamber the horizontal rudders turn the torpedo upwards, and when the diaphragm is pulled away from the air chamber the rudders turn the torpedo down.

At a certain depth, of course, the pull of the spring and the push of the water pressure will be EQUAL, and the horizontal rudders will tend to keep the torpedo running level. The depth at which this happens can be adjusted by changing the tension on the spring.

The PENDULUM in the depth control device is also connected to the valves of the depth engine. The pendulum always tries to keep the torpedo running LEVEL. If the torpedo heads upward, the pendulum will swing back and operate the depth engine to steer the torpedo down. If the torpedo heads down, the pendulum will try to steer it up again.

The pendulum and the diaphragm are INTERCONNECTED so that whichever is sending the stronger signal will control the torpedo. Suppose the depth

mechanisms were set for 20 feet and the torpedo was running level at 50 feet. Then no signal at all would be coming from the pendulum. The diaphragm would be pressed hard into the air chamber and would thus be signaling for strong up rudder. The torpedo would begin to turn upward, heading more and more steeply toward the surface all the time. As the depth decreased, the signal from the diaphragm would become weaker, while at the same time, as the upward tilt of the torpedo increased, the down rudder signal of the pendulum would be becoming stronger. Thus at, say, 30 feet, the pendulum signal would become the stronger. The steering would change to down rudder. The torpedo would begin to level off, and would reach the 20-foot depth running nearly level.

If it were not for this double—or SELF-DAMPING—action, if the diaphragm alone was in control, the torpedo would reach its set depth headed sharply toward the surface. Then, while the diaphragm tried to turn it downward, the torpedo would be rising all the time. Finally it would get back down to depth but now headed toward the bottom. Thus the torpedo would HUNT—always moving above and below the proper depth but never quite attaining it.

An important thing for you to remember about the depth-control mechanism is that until the torpedo is ready to be slung in the plane the whole mechanism is locked by a screw known as the TRANSPORTATION SCREW which runs from the bottom of the torpedo up into the base of the pendulum to keep the mechanism from joggling around. THIS TRANSPORTATION SCREW MUST BE REMOVED before the torpedo is slung in the plane. The hole left by removing the transportation screw is filled by inserting another screw, known as the REPLACEMENT SCREW.

STEERING THE TORPEDO

The directional device—known as the GYRO MECHANISM—which keeps the torpedo headed in a straight line, works on quite a different principle. Here again the torpedo is steered right or left by the vertical rudders which are controlled by a STEERING ENGINE. The valves of the steering engine are operated by the gyro mechanism.

The heart of the gyro mechanism, as you might guess, is a GYROSCOPE. A gyroscope is simply a rapidly spinning wheel mounted in such a way that its axle can turn in any direction. You can see how such a mounting works in figure 38 which shows a demonstration laboratory model of a gyroscope. The gyroscope has the peculiar property that, once it is set spinning, its axis always tries to maintain the same direction. This is why a spinning top, for instance, keeps standing upright as long as it spins.

Up to the moment the torpedo is dropped, the gyroscope in the gyro mechanism is LOCKED in a position with its axle parallel to the axis of the torpedo—and thus parallel to the axis of the airplane. At the moment the torpedo is dropped, the gyroscope is set spinning and less than half a second later is automatically UNLOCKED. Now, no matter in what direction the torpedo turns as it falls, the axle of the gyroscope will keep heading in the same direction the plane was headed at the moment the torpedo was dropped. Thus, if the plane were heading north when the torpedo was let go, and the torpedo landed in the water heading 10° west of north, then the gyroscope axle would still be heading north. The axis of the torpedo would thus be turned 10° away from the axle of the gyroscope. The gyro mechanism contains a set of levers arranged so that, when the gyroscope axle is turned away from the axis of the torpedo, the valves of the steering engine

will be set to throw the vertical rudder hard over so as to steer the torpedo back toward the direction in which the gyroscope is pointing.

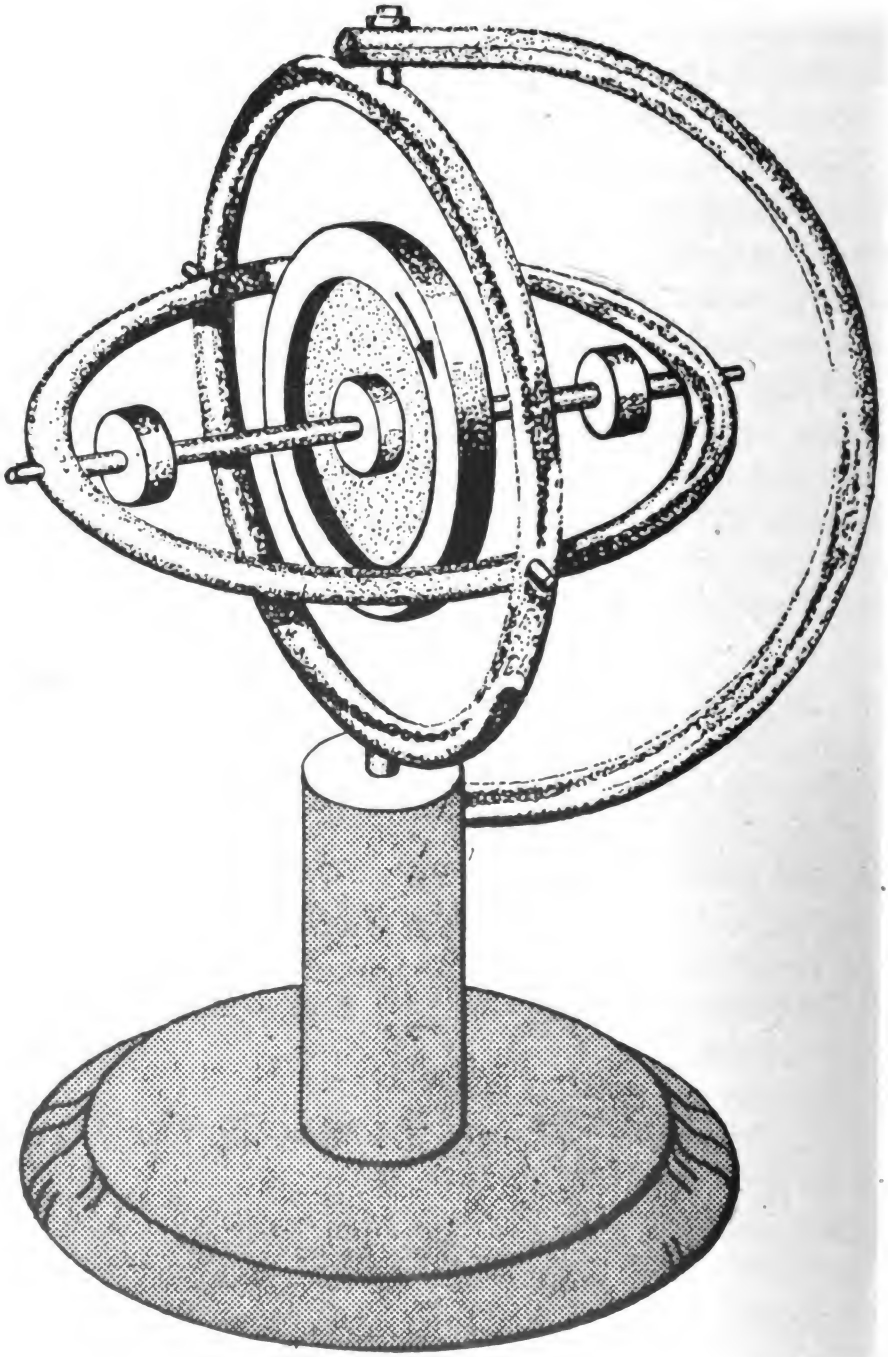


Figure 38.—How a gyroscope is mounted to give it freedom of movement.

Thus the pilot is heading his airplane toward the target as he drops the torpedo. If the torpedo lands headed in some other direction, it will turn itself back toward the target and then hold a straight line in that direction.

HOW A TORPEDO STARTS

During the time that the torpedo is being carried by the airplane, and even at the instant it is dropped, none of the complex mechanisms described above are operating. The compressed air which runs the torpedo is held away from the machinery by the STARTING VALVE.

At the top of the torpedo, to the rear, is a small lever known as the STARTING LEVER. A TOGGLE hooked to the lever is attached to the plane by a lanyard. When the torpedo is dropped, the lanyard is jerked, pulling

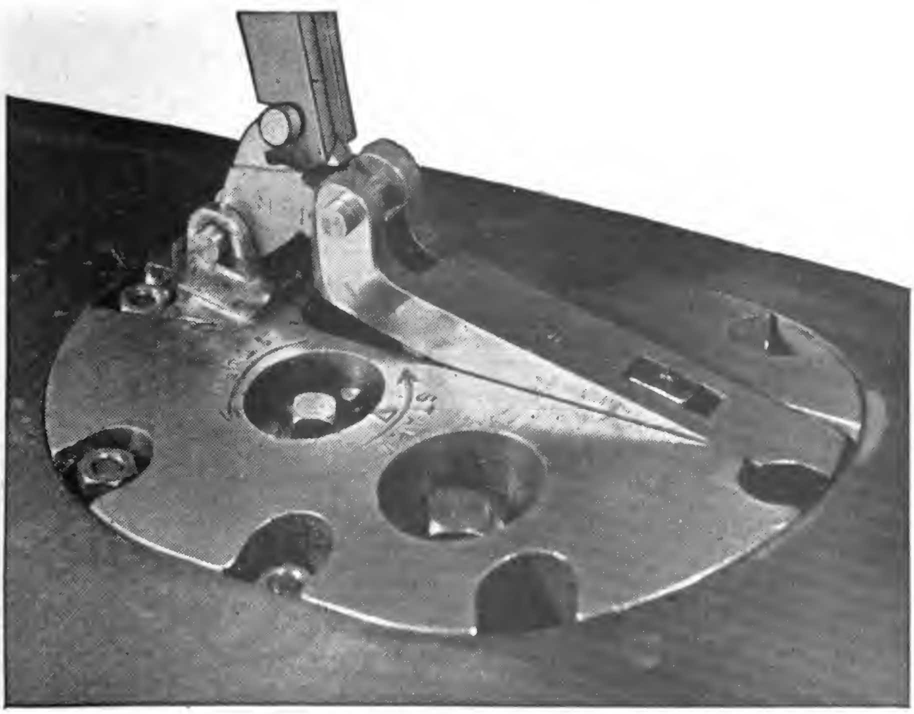


Figure 39.—Torpedo starting lever being tripped by lanyard and toggle.

the toggle away from the torpedo and tripping the starting lever.

Movement of the lever opens the starting valve and also admits high pressure air to a little turbine which sets the gyroscope spinning and operates the gyro unlocking mechanism. At the same time, the starting valve opens and admits air to the reducing valve, whence it passes through the combustion flask to the main drive turbines.

Now everything is in operation except that the alcohol which is being forced into the combustion flask is not burning. The alcohol is set afire by a device called the igniter. In this device, air pressure from the starting valve drives forward a piston carrying a firing pin. The firing pin strikes a primer which explodes and sets off an igniter mixture of black powder, cellulose and magnesium. The burning of the mixture ignites the alcohol spray.

Air pressure is not admitted to the igniter until a flap on the side of the torpedo is flipped over as it enters the water. Thus the torpedo runs cold while it is falling through the air.

To avoid accidents, the air pressure line is kept disconnected from the igniter until just before the torpedo is loaded into the airplane.

SECTIONS OF THE TORPEDO

To make it easier to maintain torpedoes in service, they are manufactured in three main sections which can readily be disconnected from each other.

The forward section is either the warhead or the exercise head, depending on the use being made of the torpedo. The WARHEAD contains the explosive charge, the exploder, and a ballast weight which keeps the torpedo from rolling sideways. The exercise head con-

tains water blowout gear and sometimes a light to make it easier to recover the torpedo at night.

Aft of the head is the AIR FLASK SECTION. Nearly all the space in this section is taken up by the air flask itself, but the section also contains the fuel flask and water compartment and the stop valve.

Next comes the AFTERBODY. This is the most complex portion of the torpedo and contains nearly all the working parts. In the afterbody are the driving turbines and reduction gearing and the depth control and gyro mechanism as well as the depth engine and the steering engine. The starting lever and the depth-setting index are on the outside of the afterbody. Attached outside the forward bulkhead of the afterbody are the starting valve, the pressure-reducing valve, and the combustion flask. These are all located in the space between the afterbody and air flask section. Openings in the side of the torpedo admit sea water into this space to keep the combustion pot from getting too hot. At the extreme rear is the tail section which carries the tail vanes, the horizontal and vertical rudders, and the propellers.

MOUNTING A TORPEDO IN A PLANE

What you, as an Aviation Ordnanceman, will have to do to torpedoes most often is to get them mounted properly in an airplane and ready to drop.

Torpedoes are not hung by suspension lugs from racks as bombs are. Instead, two racks are used—one on each side of the torpedo—with suspension cables running between them around the torpedo. (Fig. 35.) To drop the torpedo, one end of the cables is let go, and the torpedo falls away. The suspension cables have turnbuckles in them so that they can be brought up tight. To prevent fore-and-aft slipping of the torpedo in its cables, a small stop-bolt projects downward

from the airplane into a hole provided for the purpose in the torpedo casing.

In order to make the torpedo fall properly through the air, you have to attach a stabilizer to it. (Fig. 41.) This is simply a big tail fin very much like the box tail of a bomb, except that it is made out of light wood. It is slipped in place over the torpedo in such

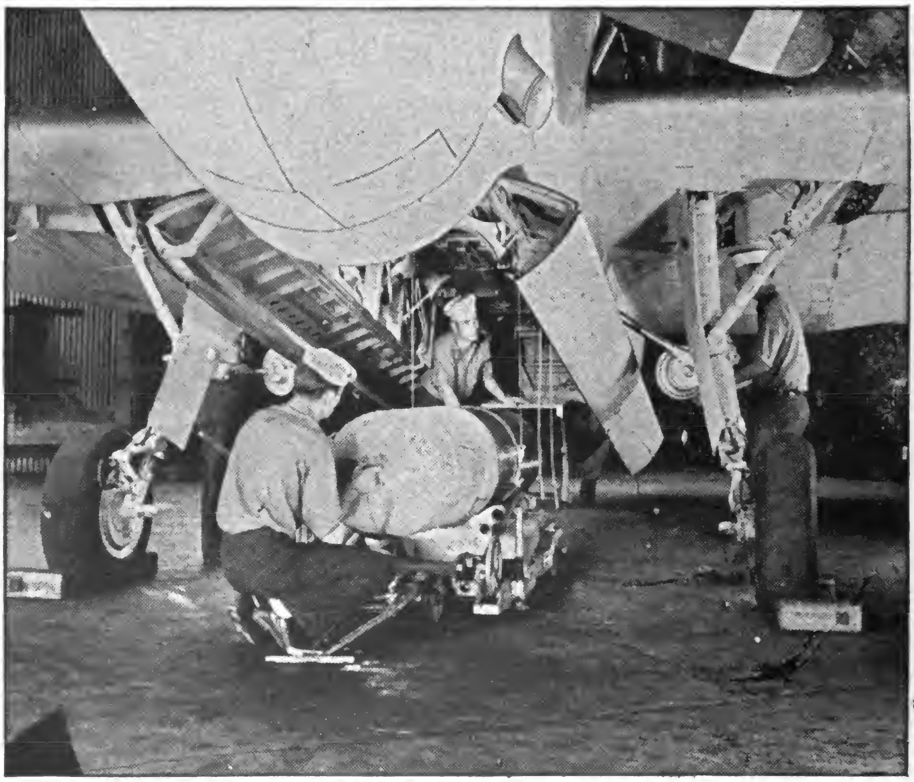


Figure 40.—Hoisting a torpedo into the bay of the TBF-1.

a position that the steel tail vanes of the torpedo fit into slots inside the stabilizer. Then it is wired in place by means of small holes drilled in the vanes. This stabilizer breaks up when the torpedo hits the water.

The purpose of the stabilizer is to make the torpedo fall in a smooth curve so that it will enter the water nose first. Otherwise, it would land flat in a "belly-whopper" which would put a terrific strain on the torpedo and very likely cause it to break up. The flap

you see on the underside of the stabilizer is held out by the wedges when the torpedo first drops and starts it heading downward. Then the wedges are yanked out by a wire connected to the plane, and the flap closes.

The same purpose is served by a drag ring—a new device which is beginning to be installed on torpedoes. This is simply a plywood tube open at both ends. It is

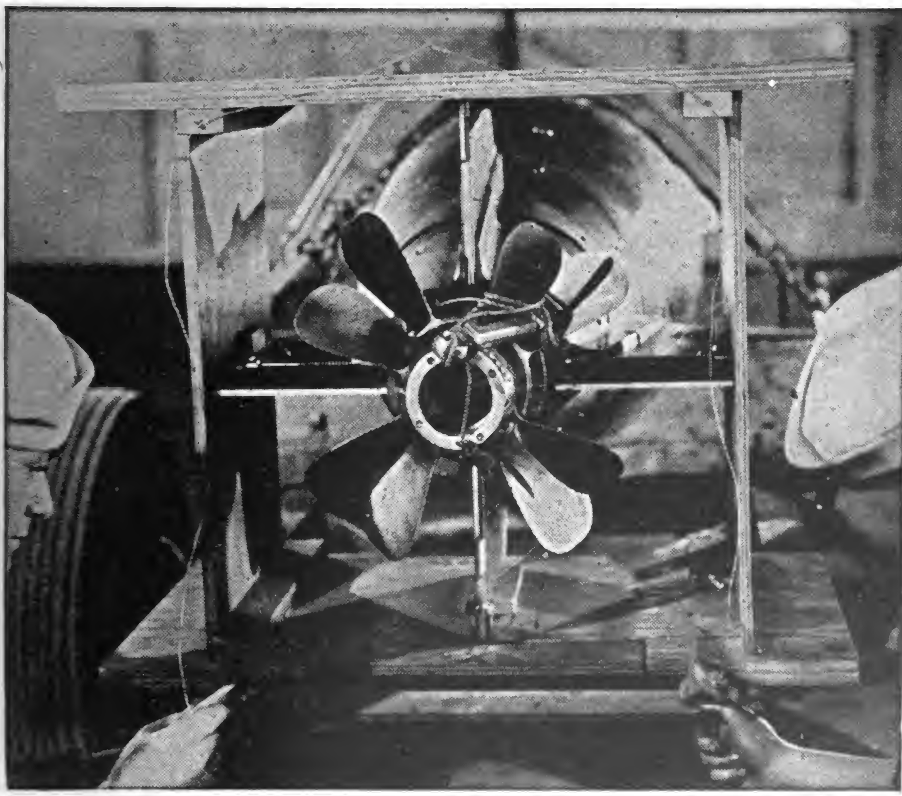


Figure 41.—This is what the auxiliary stabilizer looks like from abaft the torpedo.

slipped over the nose end of the torpedo and held in place by a bar of wood pushed through the eye-bolt in the torpedo's nose. This forms an airpocket at the front of the torpedo and, for some reason not yet clearly understood, it causes the torpedo to wobble less as it falls. It slows its fall and acts as a shock-absorber on impact with the water.

STEP BY STEP

A torpedo is delivered to the airplane and you are to load it aboard. What do you do?

Torpedomen and aviation ordnancemen usually work together when installing a torpedo in a plane. The torpedomen make the last adjustments on the torpedo, and the AOM hoist it into the airplane. But in the rush of re-arming under battle conditions, you may sometimes have to take over these final duties of the torpedomen, so you should be familiar with them.

Here is what the torpedomen do at the plane.

First step is to set the desired depth of travel for the torpedo. This is done by turning a small dial located on the top of the torpedo, just forward of the starting lever. As you know, the depth chosen will depend upon the type of target being attacked.

If the stabilizer and drag ring (if one is being used) have not been attached to the torpedo, attach them now.

Remove the transportation screw from the depth control device and replace it with the replacement screw.

Open the stop valve on the top of the torpedo all the way and then back it off one quarter of a turn.

Set the speed screw at the bottom of the torpedo up tight. This is the screw which adjusts the pressure in the pressure reducing valve. It is left loose until the last moment in order to ease off on the powerful spring which this valve contains.

When an exercise head is used, the blow valve must be open.

Check the arming wire on the exploder impeller.

At this point YOUR work starts. You should already have checked the proper operation of the racks and release mechanisms of the plane. Now open the turnbuckles on the suspension cables about three quarters

of the way and attach one end of each cable to one of the bomb racks.

Place a hoisting band around the torpedo and attach nose and tail lines to the torpedo to help you steady it as it is hoisted.

You may now hoist the torpedo up to the rack, being sure that the stop-bolt slips into the matching hole in the torpedo.

Swing the suspension cables around the torpedo and attach the free end to the bomb rack. Now tighten up

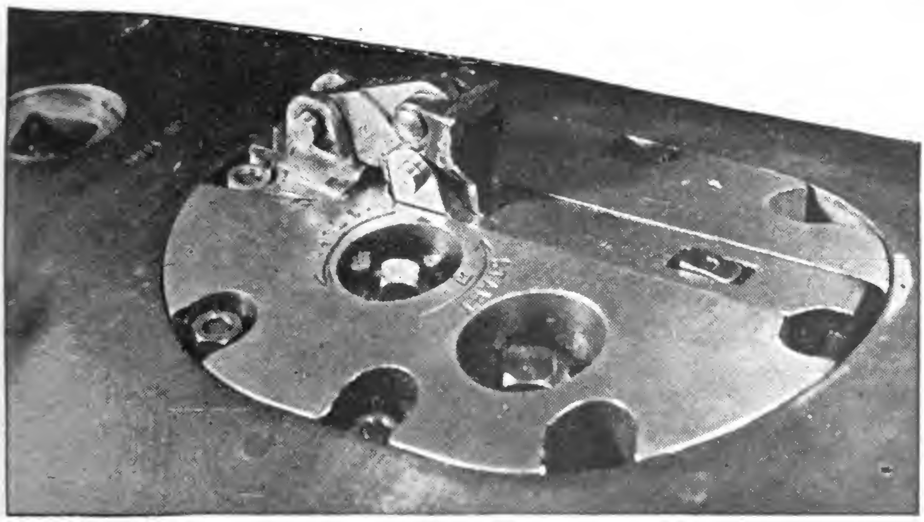


Figure 42.—Safety wedge locking starting lever in place.

on the turnbuckles and release the hoisting cables. Attach the elastic pongee cord to the suspension cables. This will keep them from slapping around after the torpedo has been dropped.

Remove the hoisting band. Now the TORPEDOMEN have more work to do.

First they will attach the starting lanyard to the toggle of the starting gear and will remove the small wedge which is fitted into the starting lever to prevent its being pulled accidentally (fig. 42). In older torpedoes, a wire is wrapped around the body of the tor-

pedo to hold down the starting lever. If this is the case, cut the wire.

Next they will remove the brass propeller lock which prevents rotation of the propellers. Leave the figure-eight loop of insulated electric cable around one set of

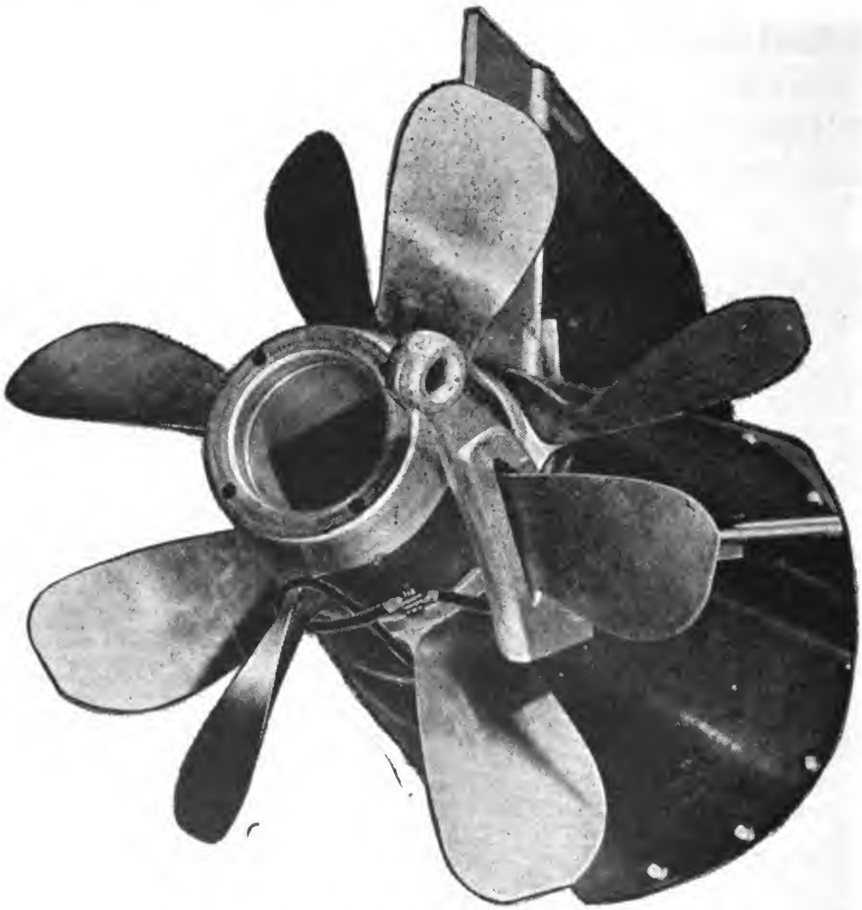


Figure 43.—Propeller lock and wire guard.

blades of the propellers (fig. 43). This will prevent the propellers from turning until the torpedo starts to run. Then the propellers will cut the cable.

Finally, the air line is hooked up to the igniter (fig. 44).

One final job remains for YOU to do. Close the bomb bay doors and make sure that there is clearance between the doors and the torpedo. Sometimes, it is nec-

Figure 44.—Attaching the air line to the igniter.

essary to cut down the stabilizer a little to clear the doors.

HOW TO CATCH A TORPEDO

Another job you are likely to encounter as an Aviation Ordnanceman is the RECOVERY of practice torpedoes. As you know, torpedoes that are dropped for practice shots surface at the end of their run, because the water ballast in the head is blown out by air pressure.

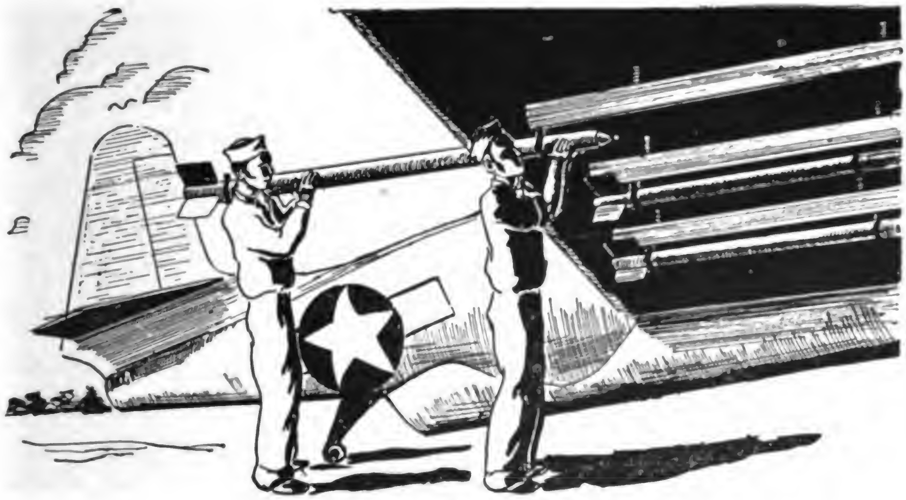
You usually go out to recover torpedoes in a small power boat. You should take along a set of 3-inch manila NOSE LINES—one for each torpedo to be recovered—and a set of manila TAIL LINES ending in a slip noose of wire cable which can be hauled taut around the tail of the torpedo. You will also need TOOL NO. 227 from the torpedo tool box. This is a wrench to operate the stop valve on the torpedo. Better take two in case one gets lost over the side. You'll also need a brass PROPELLER LOCK for each torpedo you recover.

When you've sighted a torpedo, approach it from the LEE side. Point the boat's bow at the HEAD END of the torpedo, since the sections which would be injured by a collision are at the rear.

Now pass the nose line through the nose ring on the torpedo. Then run the free end of the nose line through the loop of the tail line so that the loop can be slipped over the torpedo from the nose and worked aft. When you have the loop of the tail line to the rear, draw it tight around the tail. (If the torpedo is floating vertically, secure the nose line and go ahead slowly on the boat's engine. The torpedo will then float horizontally and the tail line can be passed and secured.) With the torpedo secured in the horizontal position, CLOSE THE STOP VALVE and secure the propeller lock.

When the torpedo has been secured, inform the ship by signal and return to the ship.

In torpedo recovery operations as in all other handling of torpedoes, remember that they are DELICATE and EXPENSIVE mechanisms and must be treated with care. Remember, too, that a ready torpedo contains air under 2,800 pounds pressure. Air at that pressure is practically an explosive, and a drop or jar which would involve no danger of setting off TNT might break a torpedo air flask case and cause a disastrous accident.



CHAPTER 6

ROCKETS AND ROCKET LAUNCHERS

A SURPRISE FOR THE ENEMY

Somewhere in the Pacific, a Jap light cruiser is getting ready to repel a minor attack. An American fighter plane has been sighted. In the distance, low to the water, the little fighter is starting its run. Gun crews duck behind their blast shields for the expected machine gun strafing. The dual-purpose anti-aircraft guns begin firing, while the machine gunners wait for the airplane to come within range.

Suddenly, long before the airplane is close enough to start strafing, a flash and a streak of fire appears under her wings, shoots out hundreds of feet ahead of her—another—another—another—a fraction of a second apart.

A few more seconds, and then while machine gun bullets sweep over her deck, the cruiser reels from the explosion of big shells in her innards.

In the Atlantic, a German sub, at periscope depth, has sighted a plane and is starting to dive. The Nazi skipper isn't much worried. He has plenty of time to

dive before the oncoming airplane will be close enough to drop depth bombs. And anyway the plane doesn't look big enough to be carrying bombs. Then, in his periscope, he sees that same streak of fire. There is a crash as a 3-inch slug of steel smashes through the side of his vessel. Frantically he tries to surface, while water pours through the hole in the hull.

American airplanes today are mounting a brand new weapon, the ROCKET—a weapon with the hitting power of heavy artillery but light enough and easy-acting enough to be mounted even in fighter planes.

Until very recently, the airplane had two major weapons—the small caliber gun, primarily intended for use against other aircraft, and the bomb for use against ground targets. Both have their advantages and disadvantages. The bomb is big and powerful. But it is hard to aim, because it falls in a pronounced curve, instead of shooting forward in a nearly straight line. Also, unless dropped from great heights, it lacks penetrating power. This is because its velocity of 600 to 900 feet per second is so much less than the 2,700 feet per second velocity of a shell from a gun.

Aircraft guns and cannons shoot projectiles which travel in a fast flat curve that makes aiming comparatively easy. But they are all small. The biggest gun in most airplanes is the 20 mm cannon, though some fighters mount 37 mm cannons. A 75 mm cannon has been mounted in certain medium bombers, but a gun of this size puts a terrific strain on the airplane because the recoil force, or "kick," increases rapidly as the gun gets larger.

So, until the rocket came into use, the biggest projectile that most airplanes could shoot weighed about 2 or 3 pounds. But a rocket-carrying fighter plane can shoot a 45-pound high explosive body in a fairly flat trajectory and with a speed of 1,600 feet per second.

Men have known about rockets for a long time. As

a boy, you probably shot off skyrockets on the Fourth of July, and until you knew better, you probably thought it might be fun to point the skyrocket toward someone you didn't like instead of at the sky.

Late in 1943, the U. S. Navy began to point rockets at people it didn't like—grown-up rockets that hit with nearly the destructive power of a shell from a 5-inch gun instead of making pretty patterns in the sky.

Did you ever wonder what makes a rocket go?

Well, it's the same thing that made your shoulder sore the first time you fired a rifle—RECOIL or kick.

When you fired the rifle, the bullet shot FORWARD and the gun jumped BACK. You may not have realized it, but the gun was pushed back just as hard as the bullet was pushed forward. The only reason the gun didn't travel as far and as fast as the bullet was because it was heavier and because you were holding on to it.

If the gun had been lighter and were free to move, it would have flown through the air. By turning it around, you could use the gun as the projectile. And if the gun were a machine gun and went right on firing as it flew, it would speed up each time it fired a bullet and would fly faster and faster.

That's the way a modern aircraft rocket works. The "gun" is nothing but a long tube, called the MOTOR, with an opening at the rear. It carries a charge of powder like the charge in the rifle cartridge except that it is bigger and burns more slowly. The motor doesn't shoot bullets. Instead it shoots out particles of gas produced by the explosion of the powder.

Shooting a stream of gas particles to the rear produces a kick, just as shooting out a stream of bullets would. And this sustained kick makes the motor fly through the air at ever-increasing speed as long as the powder charge is exploding. When the charge is used

up, the motor continues forward in free flight at whatever speed it has already picked up.

Figure 45 shows you what happens in more detail. When the charge burns, it generates gases. They cannot escape through the rear opening as fast as they are created, so a pressure is built up. This pressure acts on the sides and ends with an equal force per square inch.

The pressure on the sides cancels out. The pressure on the front end creates a force driving the motor forward. This force is resisted by the rearward pressure

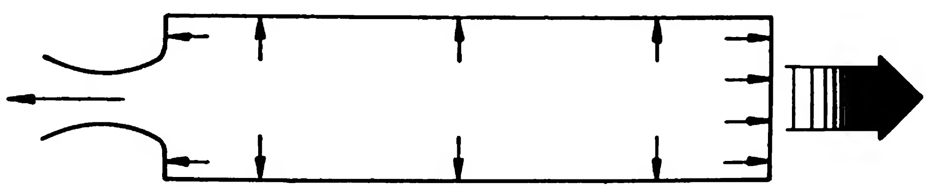


Figure 45.—Forces acting in a rocket motor.

on the back end. Because of the opening, the after end has less surface than the fore end. So the force on it is less, and the difference provides a force to drive the rocket forward.

A shell, very much like an artillery shell, is attached to the head end of the motor. When the shell, with the motor behind it, hits the target, it will be traveling at a high velocity. It will penetrate into the target and a fuze will make it explode.

This shell is known as the ROCKET BODY.

Only one type of motor is now used by the Navy in forward-firing aircraft rockets. This is a tube, 3¼ inch in diameter and nearly 4 feet long. The interior is narrowed at the rear to form a nozzle and increase the velocity of the expelled gases. The motor contains a propelling charge of BALLISTITE—an explosive very similar to the smokeless powder used in guns. It also contains an electric squib to ignite the ballistite. Elec-

Figure 46.—An aircraft rocket, assembled and loaded into a launcher.

tric wires from this squib lead out of the motor, through the nozzle, to a plug connector which can be plugged into the electric system of the airplane. This wire is called the PIGTAIL. When the ballistite begins to burn, the pigtail is melted and blown out the rear.

The motor tube is threaded forward to fit into the rocket body.

The rocket is suspended in the airplane by two T-shaped SUSPENSION LUGS attached to metal bands which are bolted around the motor.

A stabilizing FIN or tail is used to keep the rocket traveling straight. It has four sheet-metal fins attached to a tubular sleeve which slips over the rocket motor. This sleeve is slid over the rear of the motor until it hits the first suspension lug band. Then it is fastened in place by a tail locking ring which screws on to the threaded portion at the rear of the motor.

Three different rocket bodies are used—two of them 3½ inches in diameter and the third 5 inches in diameter.

One of the 3½-inch bodies is simply a solid slug of steel. This pointed slug, which weighs 20 pounds forms a semi-armor piercing projectile. Used against submarines, it carries no explosive charge—it simply punches a hole in the target.

Another, also 3½ inches in diameter, carries an explosive charge of TNT. This body also weighs about 20 pounds. Since it has an explosive charge, it needs a

FUZE to set it off. A nose fuze is used which is quite similar to a bomb fuze. The Mk 149 fuze is the most common. It is armed by the rotation of small ARMING VANES which spin as the rocket flies through the air. However, it contains a device to prevent it from becoming armed until the motor has stopped burning. Thus, during the first few hundred feet of its travel, the rocket is safe and will not explode if it strikes anything. This is to protect the plane from being injured as a result of the rocket exploding too near by.

An earlier fuze, the Mk 148, is sometimes used. This operates in much the same manner as the Mk 149, but is not quite as reliable. It has a smaller thread diameter than the Mk 149, so an ADAPTER RING must be used in order to screw it into the fuze body. This ring is furnished with the fuze.

The most powerful rocket body is the 5 incher. Its 46½-pound body carries an explosive charge of TNT and has TWO FUZES to detonate the charge. The two fuzes give greater assurance that it will explode when it hits the target. If one doesn't operate, the other one probably will.

In the nose, it uses the Mk 149 or 148 fuze.

The second fuze is screwed into the BASE of the body, where it is covered by the motor. This fuze, the Mk 146, is armed by the pressure of the gases generated in the motor. Like the nose fuze, it contains a device to prevent it from arming until the motor has completed burning. The Mk 146 is shipped with the rocket body, already installed. This fuze has a slight delay, so when penetration is desired, it is used alone—with a DUMMY NOSE PLUG replacing the nose fuze.

Both high explosive bodies are shipped with an auxiliary booster, Mk 3, fitted loosely in the nose fuze seat liner. DON'T LET IT FALL OUT.

HOW TO HANDLE ROCKETS

Rockets are always shipped with the motors disassembled from the body and they should be kept disassembled until just before they are loaded on the airplane. This is very important.

NEVER STORE ROCKET MOTORS WITH THE BODY ASSEMBLED TO THEM.

A rocket motor is a comparatively harmless thing as long as the body is NOT on it. The two ends are covered only by light transportation caps, and if the ballistite charge in the motor becomes ignited, these will blow off. Thus there will be little opportunity to build up pressure inside the motor, and the ballistite will usually burn quietly.

On the other hand, when the body is assembled to the motor, one end of the motor tube is CLOSED. If the ballistite is ignited, the motor will start traveling, and both the flying projectile and the stream of flame from the back of the motor will be EXTREMELY DANGEROUS.

The ballistite filling of a rocket motor is quite similar to smokeless powder, and motors therefore are stored in smokeless powder magazines. It is important that they be kept out of the direct rays of the sun and not stored where the temperature is over 120° F. If ballistite is too warm when it is fired, excessive pressures will be built up and the motor will very likely explode. The SAFE FIRING TEMPERATURE is stamped on each rocket motor.

If the motor has been exposed to a temperature higher than the safe firing temperature, it should be put in a cool place for AT LEAST SIX HOURS to let it cool down thoroughly.

Rocket bodies are essentially the same thing as shells and may be stored in regular shell magazines. Similarly, the rocket fuzes may be stored with bomb or shell fuzes in the regular fuze lockers.

A complete round of rocket ammunition should not be assembled until just before the rocket is to be loaded on the plane.

NEVER ASSEMBLE ROCKETS IN A MAGAZINE.

First step in preparing a rocket is to unscrew the TAIL LOCKING RING from the rear of the motor and remove the rear shipping cap. Slide the TAIL ASSEMBLY over the rear end of the motor until it butts against the rearmost suspension lug band. Be sure to line up the tail assembly so that the suspension lugs are MIDWAY between two of the fins. If you don't, the fins will foul the rocket launcher. Screw the tail locking ring back on and tighten it with a wrench.

Next insert the nose fuze, Mk 148 or 149, or the dummy nose plug. Be careful not to let the Mk 3 auxiliary booster fall out of the fuze cavity.

Finally, remove the transportation cover from the forward end of the motor. Then screw the motor into the recess of the rocket body, until it comes up solid. If the 5-inch body is being used, you will have to remove the transportation plug in the base of that body which covers the Mk 146 fuze.

When assembling rocket ammunition or handling assembled rockets, be careful not to BEND the tail fins or injure the pigtail or igniter cable which comes out of the rear end of the motor. In particular, DO NOT STAND THE ASSEMBLED ROUNDS ON END, as this may damage the pigtail. Lay it on its side.

HOW A ROCKET IS FIRED

If a rocket is to do any good, it has to be aimed. This is done by running it on a rail for the first few feet of its travel. The rail, known as a ROCKET LAUNCHER (figs. 46 and 47), is simply a box-type beam 7½ feet long and 3⅝ inches deep, built up of aluminum sheet. It has a SLOT at the bottom. The

T-shaped suspension lugs of the roc[illegible] into this slot from either end.

A SPRING LATCH aft pushes up to allow the suspension lugs to be thrust past it. Then it snaps down and prevents the rocket from falling backward out of the launcher. A pivoted TRIGGER ARM drops down in front of the rearmost suspension lug to prevent the rocket from slipping forward. This arm is held in place by a SHEAR WIRE. When the rocket fires, the force of the motor builds up to about 400 pounds and breaks the wire, permitting the rocket to go forward.

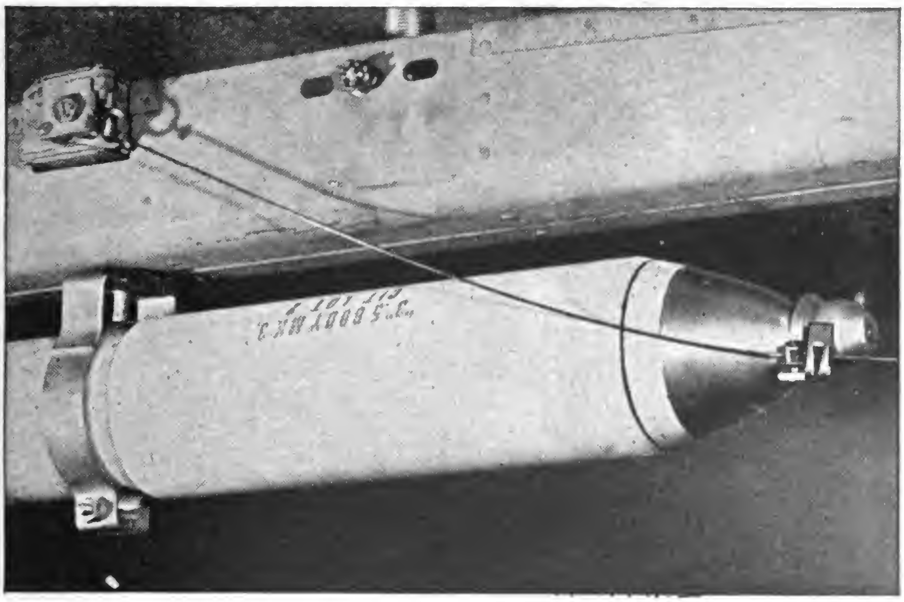


Figure 47.—Arming wire arrangement on rocket.

Attached to the side of the launcher, at the forward end, is an ARMING CONTROL MECHANISM. This has an arming wire hook, very much like the arming wire hook on a bomb rack, to which the brass plate at one end of the arming wire is fastened. If the arming control mechanism is set for SAFE, it will let go of the arming wire and the nose fuze will NOT arm. If set for ARM, it will hang on to the arming wire and thus pull it out of the fuze when the rocket is launched.

Rocket launchers are usually attached to the underside of the wing. They are fastened to the wing structure by two threaded posts, in much the same way that machine guns are mounted. The launcher itself is attached to the post by crosswise threaded studs (fig. 48). By screwing the studs back and forth and the post up and down, you can boresight the launcher to make it parallel to the axis of the airplane.

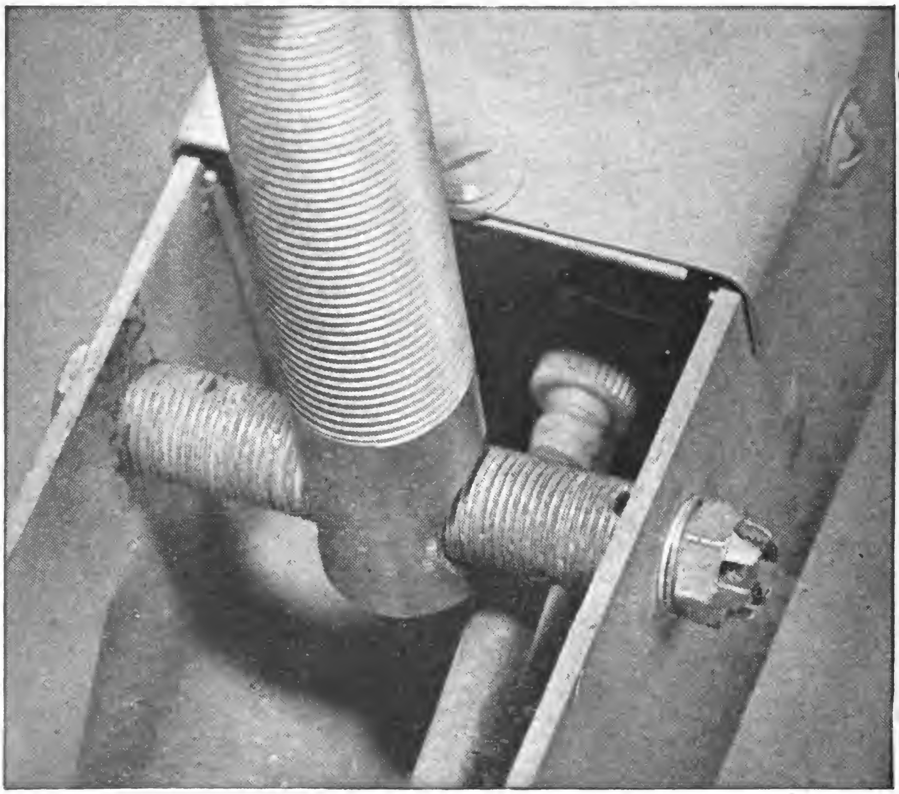


Figure 48.—By turning these threaded studs, you can boresight the launcher.

At the rear of the launcher there is an electric socket to receive the ignition wire from the motor. A short cable lead ends in a plug which may be plugged into the firing circuit of the airplane.

LOAD ROCKETS CAREFULLY

Loading rockets is a very simple operation but it

must be done with extreme care. Rockets are still new and unfamiliar. They are MORE DANGEROUS to handle than older weapons for which safety devices have been worked out over a long period of time.

NEVER STAND DIRECTLY IN FRONT OF OR BEHIND AN ASSEMBLED ROCKET and don't let anyone else stand there. Always stand at one side while you are working on a rocket.

Always be sure that the airplane is pointed in a direction where the rockets will do no harm if they go off.

Always be sure that ALL SWITCHES in the firing circuit are OPEN when loading the rocket.

First step in loading the rocket is to make SURE that the master armament switch and the firing switch are in the "off" position and that the SAFETY PLUG in the electric circuit is pulled out. First, load the launcher nearest to the fuselage, and move outward along one wing. Then load the launchers on the other wing.

Two men should lift the rocket, one holding the body and the other the tail. Slip the forward T-lug into the BREECH of the launcher and slide it forward. The rear stop will spring out of the way, and the trigger arm will rise to allow passage of the lug. Then push the rocket forward, engaging the rear lug in the same manner. Slip the rear lug past the trigger arm and then move it backward until it seats snugly against the backstop. Push the trigger arm down and insert the SHEAR WIRE, which is furnished with the rocket. This fastens the trigger arm and so locks the rocket to the launcher.

Hook the loop in the igniter cable over the catch which you will find on the rear of the launcher, but do not plug in the igniter cable. Let it hang loose.

Load all the launchers in this fashion.

If explosive bodies are being used, the next step is to attach the arming wires to the arming control mech-

anism and to thread the wires through the nose fuzes. Lock the wire in place in the fuze with a fahnstock clip—just as with a bomb fuze—and cut the wire off about 2 inches beyond the clip. Remove any burring with emery or sand paper.

Upon signal from the Safety Officer, plug in the igniter cables starting with the one closest to the fuselage.

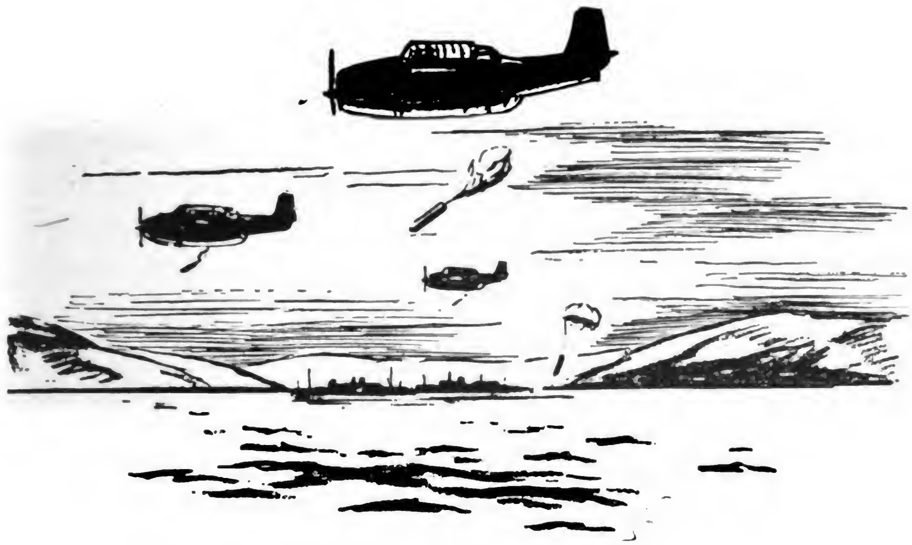
Be VERY CAREFUL, as you plug in the cables, to stand to one side of the rocket. It might fire.

After the plane is in the air, the pilot places the station distributor switch on "1," and the master armament switch and the firing switch on "on" and inserts the safety plug.

If a plane returns with unfired rockets, take out the safety plug, put the master armament switch and the firing switch on "off" and unplug the igniter cables. Remove the arming wires, first replacing the safety pin in the fuze. Remove the shear wire from the trigger arm. Then, by lifting the spring-loaded backstop, you can withdraw the rocket from the breech end of the launcher.

After all rockets have been removed from the plane they should be DISASSEMBLED unless they are going to be reloaded immediately.

Aircraft rockets are mighty effective weapons, but they are among the most dangerous pieces of ammunition you are ever called upon to handle. Treat them with care and respect and you won't get hurt. If you feel like being careless, STAY AWAY FROM ROCKETS.



CHAPTER 7

MINES

A WALL IN THE OCEAN

Can a wall be built in the ocean? As an Aviation Ordnanceman you may have to try.

How can you do it? You do it with MINES.

Mines are big explosive charges submerged in the water. They lie quietly until a ship comes by, and then they explode, shattering or crippling the ship. If a few dozen or a few hundred of these mines are spaced outside a harbor or in a channel, no enemy ship can get through until the mines have been swept up.

Mines are nothing new. Their use in warfare dates back well over a hundred years. In fact, one of the earlier mines was developed in 1800 by Robert Fulton, the inventor of the steamboat. Mines played a decisive role in the last war. The German fleet was bottled up in its home port throughout the latter part of the war when the Allies laid hundreds of thousands of them in the North Sea—the famous North Sea Mine Barrage. In this war, new developments such as the MAGNETIC

MINE and the laying of mines from aircraft have further increased their importance.

There are many different sorts of mines—FREE-FLOATING mines, MOORED mines which are kept in one place by fastening them to anchors on the sea bottom, and GROUND mines which simply lie on the bottom and explode there. CONTROLLED mines are fired by means of long electric lines running ashore. CONTACT mines go off when a ship bumps into them. The newest type is the INFLUENCE mine, which explodes when a ship merely passes near it.

Mines laid from aircraft are all of the GROUND INFLUENCE type. That is—they lie on the bottom and explode when a ship passes near.

Are you wondering how a mine can explode when a ship merely passes NEAR it? There are several ways this can be done. If you ever put a piece of iron near a compass, you saw that the compass needle swung over. So a mine can have a delicately balanced COMPASS NEEDLE in it. Then when a ship goes by, the MAGNETISM of the ship will make the compass needle DIP.

The dipping of the needle trips a RELAY switch which sends a current of electricity from a battery in the mine to an electric squib—and the mine explodes. This is the famous magnetic mine that you used to read about in the newspapers.

Another type is the INDUCTION mine. This uses a long coil of wire. When a ship passes by, the lines of MAGNETIC FORCE around the ship cut the wires in the coil and produce an electric CURRENT in the coil—just the way current is produced in a dynamo. This current operates the relay switch which explodes the mine.

Still a third type is the ACOUSTIC mine. This contains a MICROPHONE device which trips the relay when it picks up the sound of a ship's engine.

All three of these types of influence mechanism are

used in aircraft mines. All of them, as you can well imagine, are delicate and sensitive devices. Like torpedoes, they can be serviced and maintained only by men specially trained in this work.

But just as in the case of torpedoes, ordnancemen sometimes have to handle mines to load them into planes—and should understand what they are and in a general way how they work.

HOW A MINE IS ARMED

Any high explosive ammunition carried in an airplane has to be safetied while it is in the plane, and mines are no exception. Every mine is safetied in two different ways. The electrical firing circuit is BROKEN. And, in addition, the electric primer-detonator is MOVED far enough away from the booster so that even if the primer exploded the mine would not go off.

To ARM the mine, each of these safety features must be removed. The electrical circuit is re-established by a CLOCKWORK mechanism. While the mine is above water this clock is prevented from running by a device called the CLOCK STARTER. When the mine has sunk into water to a depth of about 16 feet, hydrostatic pressure pushes the clock starter inward and permits the clock to run. After a period which varies from 45 minutes up to about 3 hours, the clockwork closes the electric circuit, and the mine is partially armed.

Contact between the electric primer-detonator and the booster is also established by a hydrostatic mechanism. It is known as the EXTENDER. When the mine is submerged, hydrostatic pressure pushes the extender inward and moves the primer detonator against the booster.

Thus the mine is always safe until after it has sunk about 16 feet under water.

When a mine is suspended in an airplane, ARMING

WIRES threaded through the clock starter and the extender prevent them from operating, even in the presence of hydrostatic pressure.

Normally, when the mine is dropped, the arming wires are fastened firmly to the bomb rack—just like the arming wires on a bomb—and the mine arms when it enters the water. If the arming wires are dropped with the mine, it will ordinarily NOT arm. YOU CAN'T COUNT ON THIS, however. Sometimes the arming wires are broken when the mine hits the water, and sometimes the blast from a nearby explosion in the water will shear the wires.

Sometimes arming of the mine is still further delayed by using soluble washers to prevent action of the clock starter and extender. As long as the washers are there, the two mechanisms cannot operate. It takes some definite number of hours or days for the washers to dissolve.

FINS AND PARACHUTES

Aircraft mines look something like bombs. They are cylindrical in shape with rounded noses. There is usually a fuze recess in the nose into which an ordinary bomb nose fuze can be screwed. This is done so that the mines can be used as bombs in an emergency. Except in an emergency, the nose fuze is either omitted or is dropped safe. Latest mines leave out the fuze recess.

The clock starter and extender mechanisms are mounted in two wells in the side of the mine. The two arming wires run up the side of the mine and are fastened to a single swivel loop or arming wire plate. This is slipped into one of the arming wire retainers of the bomb rack or shackle.

The Navy now uses two 1,000-pound aircraft mines, the Mk 13 and the AN-Mk. 26 Mod. 1. Both these

mines have roughly the same dimensions as a 1,000-pound GP bomb. They are suspended from ordinary bomb racks or shackles in much the same manner as a 1,000-pound bomb.

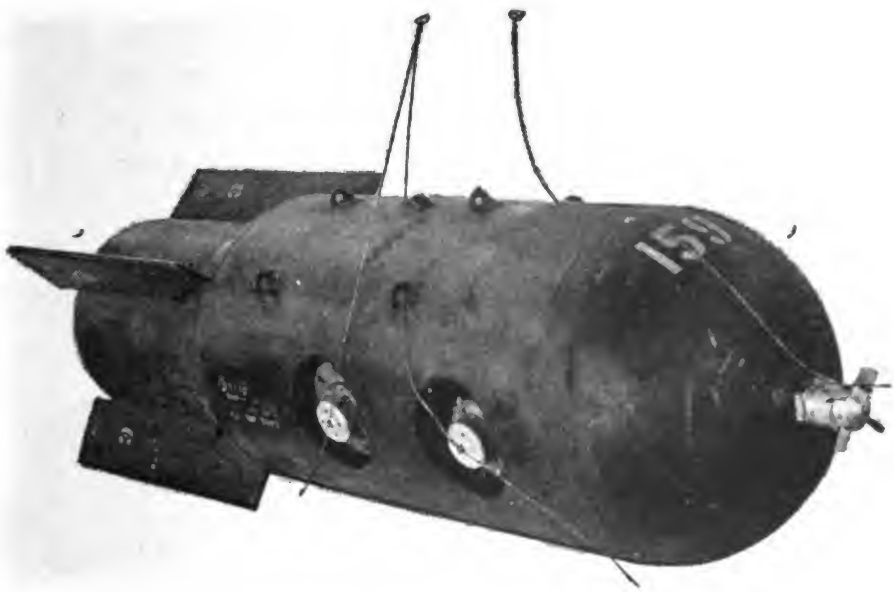


Figure 49.—Mk 13 aircraft mine.

The Mk 13 mine (fig. 49) uses either the induction or the acoustic type firing mechanism. It is ordinarily dropped from fairly low altitudes but it has welded-on FINS to make it fall through the air more evenly. Notice in the illustration that three separate sets of suspension lugs are fastened to the bomb, 45° apart. This is done because of the fixed position of the tail fin. If the mine is suspended under a wing, the center set of lugs is used. Then the tail fin will not foul the wing surface.

However, if the mine were hung against the sides of a bomb bay and this set of lugs were attached to the shackle, then one of the fins would foul the sidewall of the bomb bay. So in this case one of the other two sets of suspension lugs must be used. This problem

doesn't arise with bombs, because the tail can be rotated to avoid fouling.

Except that you have to attach arming wires to the extender and clock starter, the Mk 13 mine is hoisted into a plane and hung there just in about the same way as a bomb. When attaching the arming wires to the extender and starter, leave about 13 inches of wire dangling and slip two fahnstock clips over the wires.

The big difference between the AN-Mk. 26 Mod. 1 mine and the Mk 13 is that the former uses a PARA-

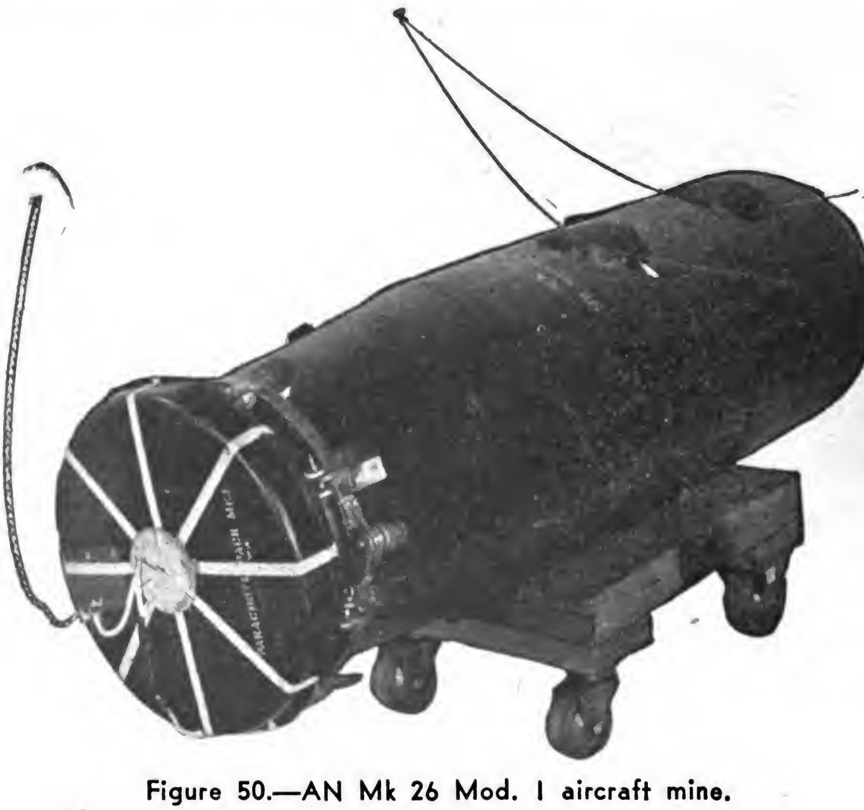


Figure 50.—AN Mk 26 Mod. I aircraft mine.

CHUTE. The parachute case can be seen fastened to the rear of the mine in figure 50. A STATIC LINE from the parachute case is fastened to some solid object on the plane. When the mine is dropped the static line rips open the parachute and then breaks. The parachute shroud lines are fastened to shackles on a METAL STRAP around the end of the mine.

When the mine hits the water the parachute strap OPENS. The heavy pin locking the CLEVIS JOINT visible at the near part of the strap is forced down by inertia, shearing a thin wire which holds it in place. Removal of the pin unlocks the strap, and pressure of the water against the flaring VANES welded to the strap pushes it open. Thus the parachute is RELEASED and the bomb sinks to the bottom.

The Navy has two larger mines, the 1,660-pound Mk 12 Mod. 1 and the 1,926-pound Mk 25. These mines are too heavy for most Navy racks and shackles and are suspended like TORPEDOES—hung from cables between a pair of racks or shackles. Both these mines

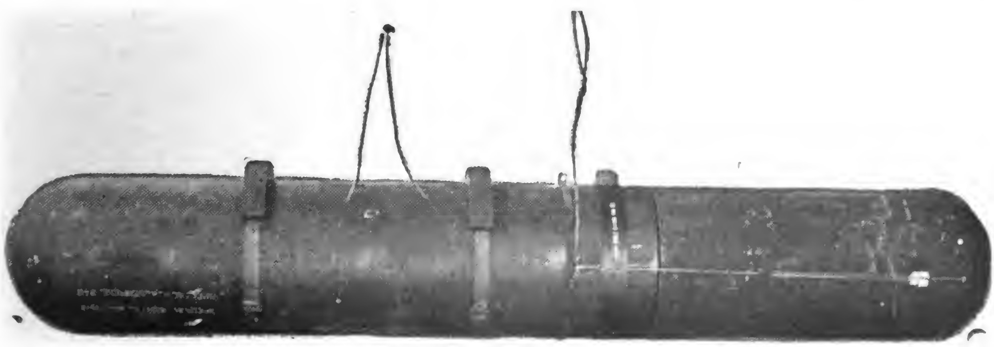


Figure 51.—Mk 12 Mod. 1 aircraft mine.

employ parachutes. Some planes, which have shackles with a 2,000-pound capacity, carry these big mines like bombs.

Figure 51 shows a Mk 12 Mod. 1 mine. The PARACHUTE is in the after portion of the body and is held in place by a metal cover. When the mine is dropped, this cover is released by a pull on the aftermost pair of arming wires. When the cover flies off, it pulls out the parachute. The parachute is disconnected from the mine when it hits the water.

The important thing for you to remember about mines is the EXTREME DELICACY of their mechanism.

They should be handled carefully, should not be jolted or dropped. If a mine is subjected to any unusual rough handling it should immediately be turned over to qualified mine men to be checked.

CHAPTER 8

PYROTECHNICS

FIRECRACKERS GROW UP

"Pyrotechnics" means "fireworks"—just like the Roman candles and firecrackers you used to shoot off on the Fourth of July. Pyrotechnics are simply fireworks adapted to military purposes.

It may sound like kid stuff but don't let that make you take a casual attitude toward Naval pyrotechnics. They are DANGEROUS unless they are handled right. The explosives and combustible materials in them are not as powerful as most other military explosives, but they are far easier to ignite and much more subject to deterioration—and plenty powerful to do real damage if they go off when they shouldn't.

Nearly all pyrotechnics are very sensitive to moisture, so they should be stored in a dry, well ventilated place. Those which come packed in moisture-proof containers should be KEPT in the containers, with seals unbroken, until just before they are used.

Remember that pyrotechnics can be more easily damaged by rough handling than other ordnance. If jolted or jarred they may go off or they may be injured so that, when they are needed, they won't go off.

Pyrotechnics should never be stored where the direct rays of the sun can strike them, and temperature in storage spaces should always be kept below 100° if possible. Of course, smoking or flame is not permitted around pyrotechnics.

Rules for STORING pyrotechnics are similar to those for smokeless powder. Pyrotechnic magazines should be at least 200 feet apart and, if possible, 400 feet. They should never be less than 400 feet from an inhabited building or highway, and 800 feet is better. On shipboard, all pyrotechnics producing smoke should be stowed above decks.

Remember that pyrotechnics DETERIORATE more rapidly than other ammunition, and always use the OLDEST serviceable pyrotechnics available first, so as to keep a fresh stock on hand.

LIGHT ON THE SUBJECT

In Naval Aviation, pyrotechnics are used chiefly to provide ILLUMINATION and for SIGNALING. In night operations, there are many times when an aviator needs to be able to light up the ground or the water beneath him. He may be coming in for an emergency landing on a field which has no light. He may want to look at enemy territory or may want to light up a night bombing target. He may simply want to drop a brilliant light which will dazzle and blind enemy anti-aircraft gunners. Or perhaps he wants to take a picture.

Two general types of pyrotechnic lights are used in airplanes—flares and flash bombs. The FLARES are containers filled with a pyrotechnic material which will

burn for SEVERAL MINUTES with a brilliant light. They are dropped with a parachute so that they will fall slowly, lighting up the area beneath them.

The FLASH BOMBS are for taking night photographs. They are used the same way a news photographer uses his flash bulbs. That is—they throw an intensely brilliant light for a FRACTION OF A SECOND. They are containers with a filling similar to the flash powder that photographers used to use. They explode in the air after they have been dropped from a plane. Usually the camera has a photoelectric device on it which will open the shutter as soon as the light from the flash bomb reaches it. Then the camera snaps its picture during the explosion of the flash bomb—a period of about 1/5 of a second.

Navy flares come packed, with their parachutes, in tubular waterproof chip-board cases. Packed with them are bands carrying suspension lugs which may be placed around the flare if it is desired to drop it from a bomb rack. Coming out of the case and taped to the outer side of it, is a RIP CORD. The operation of the flare is started by pulling this cord. NEVER PULL THE CORD. At the end of the cord is a brass plate like the plate on the end of a bomb arming wire. When the flare is hung in a bomb rack, this plate is fastened to the arming wire retainer of the rack.

Flares may be DROPPED in several ways. You may suspend them from a BOMB RACK like a bomb and release them in the usual manner. But remember, flares are MUCH LIGHTER than bombs and consequently the old Mark 35 and Mark 41 racks may not operate satisfactorily when dropping flares.

Occasionally, flares are still dropped by using a FLARE ADAPTER—also known as a flare chute or flare holder. This equipment is now considered obsolete, but to use it, simply insert the flare into the adapter, heavy end down. Secure arming plates to the rip cord

hook on the adapter, and close the adapter door. The flare will be let go when the flare release handle in the cockpit is pulled.

In an EMERGENCY, you can simply throw the flare out of the cockpit. Take an extra 10 feet of cord. Tie one end to the arming plate on the flare rip cord and tie the other end to something secure in the plane.

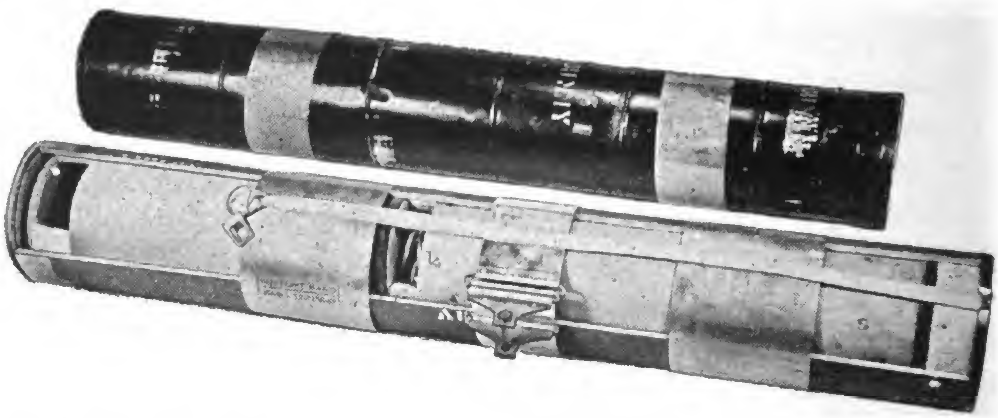


Figure 52.—A Mk 6 parachute flare. Above—It is in its container. Below—It has been removed and the outer case partly cut away.

Then throw the flare overside, heavy end down. Don't just toss it. THROW IT downward as hard as you can so as to give a good strong pull to the rip cord. If you are planning to do this and are carrying flares in the cockpit, be sure they are secured firmly—particularly if the airplane is to be catapulted.

The Navy uses a number of different flares. The simplest is the Mk 4 which burns for 3 minutes with 300,000 candlepower. This is intended for LOW ALTITUDE release, primarily for emergency night landings. When the flare is dropped, one end of the rip cord is held to the plane. The jerk on the cord breaks open the after end of the case and pulls out the parachute. Attached to the parachute shroud line is a cord running through a friction wire. When the parachute

opens, the cord yanks the friction wire through a cup of match compound—the same stuff you find on the head of a kitchen match. The friction ignites it and the flame starts the flare burning.

A somewhat similar flare is the Mk 8, which is used in antisubmarine work. In this flare, a 90-second delay is built into the ignition train. When the pilot sights a sub, he drops the flare. The parachute opens. Ninety seconds later, when he has had time to circle and prepare for a bombing run, the flare lights up. It throws 750,000 candlepower.

For bombing and reconnaissance missions you usually want to drop the flare from quite high up. But you don't want the flare to burn at that great altitude becauses then it would be too far from the ground to light it up properly. To get the best results out of a flare, it should START burning at a height of about 3,000 feet. Therefore, flares used for such work employ a special kind of FUZE which will set them off a predetermined number of seconds after they are released from the plane. Navy flares of this type have a BUILT-IN fuze which can be set for the number of FEET you wish the flare to fall before it ignites. To make the setting, remove the metal end cover and set the fuze pointer opposite the desired drop. The setting is locked by tightening a set screw so that the point penetrates the chip-board case of the flare.

When the flare is dropped, the yank on the rip cord snaps the fuze and starts it operating. After the set time interval, the fuze ignites the flare. The GASES produced by the burning flare force the parachute out of its case, and the flare floats earthward as it burns.

The Navy has two flares of this type—the Mk 5 which burns for 3 minutes with 750,000 candlepower and the Mk 6 which has the same burning time but produces 1,000,000 candlepower.

The Navy sometimes makes use of an Army flare,

the AN-M 26. In principle and use, this flare is the same as the Mk 5, but it differs radically in appearance and construction. The AN-M 26 has a BOMB-SHAPED metal case with tail fins. It does NOT have a built-in fuze. The M 111 A2 aerial burst fuze must be screwed into the nose of the flare just before it is loaded into the plane. The fuze has an adjustable time delay like the built-in Navy fuze, but it is calibrated in seconds rather than feet of fall. Therefore a table must be used to find out how many seconds you want for a given drop.

Operation of the M 111 A2 fuze is started by a regular bomb-type arming wire. A second wire, the HANG WIRE, is fastened to the arming wire plate. When the flare drops, the yank on this wire pulls out a small SLEEVE—a miniature parachute—and the hang wire breaks. This sleeve stabilizes the flare as it falls through the air. When the time fuze fires, it ignites a charge of black powder which blows the cover off the PARACHUTE, permitting the sleeve to pull it out of the case. The parachute opens, yanks a cord which IGNITES the flare and pulls the flare out of the metal case.

A peculiar feature of this flare is a SHADE which is suspended from the parachute just above the flare so that the light will not blind the men in the plane.

A PHOTO FLASH BOMB, as you know, provides a single, short, very bright flash. Naturally it has no parachute. Flash bombs look very much like Army flares. The most commonly used is the M 46. This has a metal case with tail fins like a bomb, and it is set off by the same M 111 A2 fuze which is used in the AN-M 26 flare. Thus, it can be set to go off at any altitude below the plane.

Flash bombs are even MORE DANGEROUS to handle than other pyrotechnics. They are extremely easy to set off, should never be hammered or struck. NEVER

DISASSEMBLE A PHOTO FLASH BOMB. They should be stowed in SEPARATE LOCKERS located where they cannot set off high explosives or service ammunition. It is permissible to stow not more than 10 bombs in the regular pyrotechnic magazine if a separate locker is not available.

The flash is extremely bright—half a billion candle power for the M 46—and you should never look at one when it explodes.

X MARKS THE SPOT

Remember the old fellow who cut a notch on the side of his boat to mark the place where the fishing was good? A Navy pilot out over the ocean is often up against the same problem. He sees the shadow of a submarine. He wants to turn, make a run, and drop a depth bomb. He needs some way of MARKING the place.

When a NAVIGATOR wants to know how fast his plane is drifting, he needs to watch some spot on the water. So, he has to MARK the spot. And a pencil mark on the wing to mark a spot on the water is not much good.

Several MARKERS are used by the Navy to meet this need. The Mk 1 depth charge marker for day use has a small explosive charge which blows open two containers of dye. The dye makes a yellowish green stain in the water, visible for several miles, which lasts for about 45 minutes.

AT NIGHT, the Mk 2 depth charge marker is used. You tear off two tabs to open holes in the container. Sea water enters the holes and, reacting with a filling of calcium carbide, produces ACETYLENE gas—just like an old-fashioned bicycle lamp. The container also holds a small charge of calcium phosphide to generate PHOSPHINE, a gas which has the property of igniting

spontaneously. The phosphine ignites the acetylene and keeps it burning, producing a flame about 9 inches high for nearly an hour.

The day marker has a grenade-type firing mechanism. That is, it is safetied by a small external lever which is normally held down by a cotter pin. When you want to use it, you grasp the marker so that your hand holds the safety lever down and withdraw the cotter pin. Then you throw the marker. As it leaves your hand, the safety lever springs up, the firing mechanism immediately ignites a delay train, and a few seconds later the ejection charge is fired. It takes only a small movement of the lever to fire the charge. So HOLD THE LEVER FIRMLY.

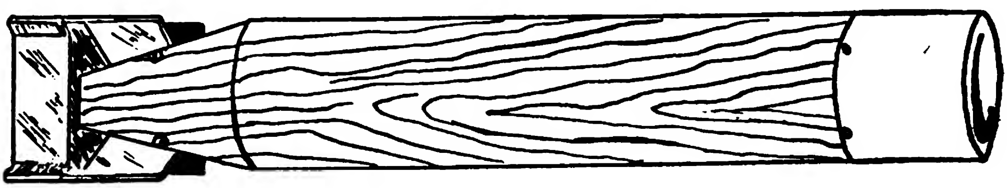


Figure 53.—Drift signal—AN-Mk 5 Mod. 1.

Although these two markers are used in airplanes, they were originally designed to be thrown from the decks of ships and may not prove satisfactory for altitudes greater than about 3,000 feet. Two signals specifically designed for aircraft use are the AN-Mk 4 and AN-Mk 5 Mod. 1, NIGHT DRIFT SIGNALS. These are small bomb-shaped devices with stabilizing fins (fig. 53) designed to be thrown overboard from an airplane. They have WOODEN bodies so that they will float and contain a pyrotechnic mixture which will burn with a bright flame 12 to 15 inches high. The flame lasts about 3 minutes in the 2-pound AN-Mk 4 and about 15 minutes in the 4-pound AN-Mk 5 Mod. 1.

In both cases, the pyrotechnic mixture is ignited by a built-in impact FUZE which operates when the signal

hits the water. A delay of 8 to 12 seconds is built into the fuse to give the signal time to float to the surface before the pyrotechnic ignites. In an emergency, you can ignite the signal by punching the fuze end with a PENCIL.

PASSING THE WORD

Pyrotechnics are commonly used as signaling devices —to enable airplanes to IDENTIFY themselves or to send DISTRESS signals. This is done by projecting one or more colored STARS—pellets of brightly burning pyrotechnic material—or a puff of colored SMOKE.

Best known of these signaling devices is the familiar VERY'S SIGNAL. You have undoubtedly read of it in stories about the last war. The signal consists of a small CARTRIDGE, resembling a 10-gage shotgun shell. The cartridge is fired from a Very's PISTOL or, nowadays, from a hand PROJECTOR, Mk 3 or Mk 4. The hand projector consists of a tube closed at one end by a BREECH PLUG which screws into the Mk 3 or is clipped with a bayonet lock, to the end of the Mk 4.

In the breech plug is a FIRING PIN and spring. The projector is fired by pulling back on the firing pin and letting go. Then the spring will drive the pin against the primer of the cartridge. The star charge is ignited and shot from the projector, burning as it rises to a height of about 200 feet. Red, white and green stars are available. The red is usually a distress signal.

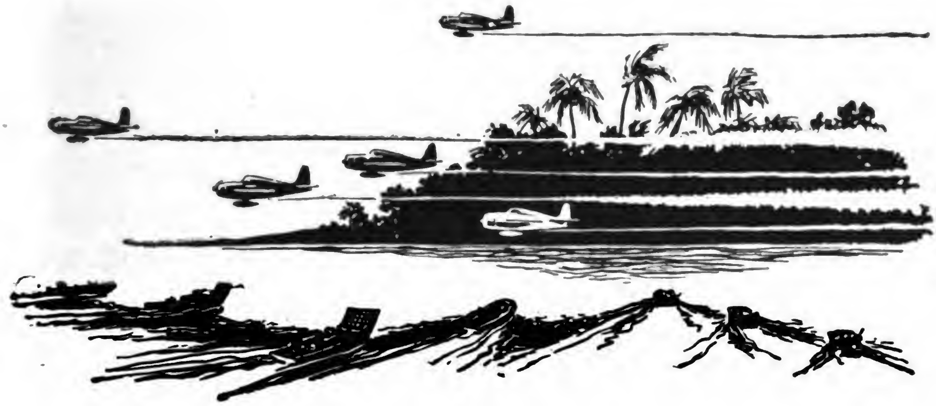
A great variety of signals can be obtained with a TWO-STAR signal cartridge. These cartridges throw two stars of the same or different colors. Six combinations of green, red and yellow are possible. One type signal cartridge obtains even more combinations by including a colored tracer. In this type, the tracer shows while the charge is rising to a height of about 250 feet. Then the stars are ignited and fall.

These cartridges are 1.5 inches in diameter and are fired from an AN-M 8 PYROTECHNIC PISTOL. This is a 2-pound projector which may be mounted in a plane to fire outward or can be held in the hand. When hand fired, the pistol has a kick slightly greater than a caliber .45 service automatic.

LONGER-LASTING stars or smokes are produced by the Mk 6 and Mk 7 identification signals. These are small aluminum cylinders with a grenade-type mechanism. You THROW them overside. The Mk 6 contains a red, white or green star, which burns for about 25 seconds, and a small PARACHUTE. The Mk 7, for daylight use, suspends a SMOKE signal—red, yellow, green or black—from the parachute.

Two other devices are particularly intended for use by GROUNDED PLANES as distress signals. One, the M 11 parachute signal, consists of a long cartridge to be fired from the AN-M 8 pyrotechnic pistol. It shoots a red star and parachute which rises about 250 feet. The star burns for about 30 seconds as it falls.

As a DAYLIGHT distress signal, the AN-M 8 WHITE-SMOKE HAND GRENADE can be used. This is a metal cylinder about 5 inches long and 2½ inches in diameter with a grenade firing mechanism. In use, it may be fastened to a special long HANDLE, clamped to an OAR, or simply THROWN to the ground some distance away. It will generate a harmless, gray-white smoke for about 3½ minutes. STAY AT LEAST 5 FEET AWAY FROM IT while it is burning.



CHAPTER 9

SMOKE

SMOKE SCREENS FROM THE AIR

Smoke equipment is the direct opposite of pyrotechnics. Pyrotechnic flares and flash bombs are used to LIGHT UP an area and let you see what's going on. SMOKES are used for CONCEALMENT, to hide something from the enemy. In a few minutes an airplane can lay an opaque wall of smoke as much as 250 feet high between our ships and the enemy. This will prevent him from knowing what you are doing, make it difficult or impossible for him to fire at you. Often, in this war, blankets of smoke have been laid over whole cities or harbors to prevent air observation of troop concentration, convoys, and the like.

There are many different ways of producing smoke, but here you will be concerned with the two devices used for laying smoke screens from aircraft—smoke TANKS and smoke BOMBS. With a smoke tank, an airplane can skim along 100 feet or so above the water, leaving a thick trail of smoke that will sink to the water and rise to twice the height of the airplane, forming an opaque wall.

From HIGHER ALTITUDES, a plane can drop a smoke

bomb into the water which will rise to the surface and float there, emitting a dense smoke.

The smoke tank now used by the Navy, the Mk 5, is a very simple device. It is just a monel metal tank suspended from a BOMB RACK and containing 50 gallons of FS MIXTURE. FS is a liquid which forms an opaque vapor of sulphuric and hydrochloric acid when it comes in contact with the air. An EXHAUST TUBE projects from the rear of the tank to guide the vapor.

The FS mixture is forced out of the tank by GAS PRESSURE supplied from a flask of compressed carbon dioxide. The carbon dioxide is led through a PRESSURE REGULATING VALVE in the cockpit to the tank. There the pressure forces the FS out if the discharge valves are open.

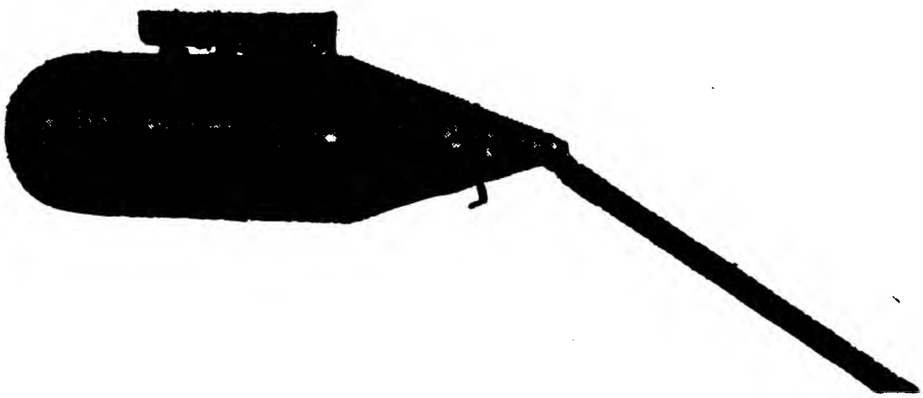


Figure 54.—Mk 5 smoke tank. Notice the swivelled exhaust tube.

The rate at which the smoke mixture is forced out can be adjusted from inside the plane by adjusting the pressure maintained by the regulating valve. A discharge valve—known as the gate valve—is operated by a lanyard leading into the plane. Another valve—on older tanks—is opened by the Ordnanceman just before the plane takes off.

The Mk 5 tank is a monel metal cylinder 5½ feet long and 19 inches across. The front end is rounded, while the after end, which contains the operating valves, tapers to a conical shape. The exhaust tube is fastened to the end of this cone (fig. 54). Two SUSPENSION LUGS like those on a bomb are located 14 inches apart on the top of the tank, so that it can be suspended from a bomb rack. Midway between the suspension lugs is a HOISTING LUG to which a line can be attached when the tank is being hoisted into the plane.

A simpler tank now coming into use by the Navy is the Army's M 33 tank. This has a 78-gallon capacity and weighs about 1,000 pounds full. It is cheaper than the Mk 5 and is usually JETTISONED after use. It discharges by GRAVITY rather than gas pressure, and has no valves. Smoke outlet and air inlet openings are closed by GLASS PLATES. When smoking is to start, these plates are broken by the explosion of small electric DETONATORS, fired from inside the plane.

Before filling the tank, you have to install these plates, with the proper GASKETS—first applying graphite grease to the gaskets—and mount the detonators.

FS mixture is usually shipped in 55 gallon DRUMS and must be loaded into the smoke tank by ordnancemen. The drums have two openings, one for drawing off the FS and one for venting the drum. It is usually more convenient to use the opening at the center of the drum to draw off the FS.

The first step is to stand the drum on end and slack off the plug in the end opening until any GAS PRESSURE which may have built up in the drum has been relieved. Then remove the center plug and screw in a pipe fitting. Attach a length of FLEXIBLE METAL TUBE with a valve at the end to the fitting. Rubber hose is ordinarily not used with FS because the mixture would attack it and destroy it in a few hours. Now make

SURE that the valve is closed, hoist the drum onto an elevated rack, and open the vent plug.

The smoke tank meanwhile should be placed on a special rack or bomb truck where it can be filled conveniently. Fill the tank slowly, GAGING it frequently with a graduated measuring rod of corrosion-resisting material or with the scale marked on some filling nozzles. Be careful not to let the FS mixture OVERFLOW.

EVERY MEMBER of the filling crew should wear rubber gloves, acid-proof clothing or apron, and a gas mask. FS gas is not poisonous but high concentrations of it will burn the skin, throat, and lungs.

If any liquid FS gets on your body, wipe it off with a piece of dry cloth. FLUSH the spot with a GREAT DEAL of water and then with a weak solution of baking soda in water. When you are washing FS off yourself or anything else be sure to use LOTS OF WATER. Small quantities will react violently with the FS and cause spattering. For the same reason, always be sure that any container which you are filling with FS is BONE DRY.

FS fumes have a corrosive effect on all airplane parts. Be sure therefore, that before you load the tank onto an airplane you flush it off THOROUGHLY with water to remove any FS you may have spilled on it. Also, be sure when filling tanks that there are no aircraft down wind of you.

LOADING a smoke tank into a plane is only a little more complicated than loading a bomb. First see that all the valves on the tank are shut, and then attach the tank to the bomb rack, just as if it were a bomb.

Now hook up the carbon dioxide line between the tank and the pressure regulator in the cockpit. These connections must be very tight.

Apply a graphite grease to the gasket on the SWIVEL JOINT where the exhaust pipe connects to the after end of the tank. Hook up the exhaust tube and be sure it

can swing freely. Then connect the exhaust tube LANYARD. Be sure that it is adjusted so that the tube can be drawn to the full up position during take-off.

Hook the other lanyard to the gate valve.

Just before the plane takes off, open the carbon dioxide valve. If the tank is an old model with two valves, open the discharge valve. You don't do this on the newer tanks.

Now watch her smoke.

Usually, tanks are jettisoned when smoking operations have been completed. If this is not done, the plane's crew should completely EXHAUST the smoke mixture from the tank by opening and closing the gate valve several times with a regulator pressure of about 20 pounds. However, whenever a plane returns with a tank aboard, you should slip some sort of rubber BOOT over the end of the exhaust tube (you can make one up for yourself).

This will prevent any last driblets of FS from getting on you or on the airplane while you are removing the tank from the airplane.

Take the empty tank to an isolated spot, remove the filling caps and close all valves, then pour about 2 gallons of SODA WATER SOLUTION into the tank. Slosh this around so that it gets all over the inside of the tank. Fill up the tank with fresh water and blow it out through the valves with air pressure. Repeat this and then dry the tank with air. Now remove the exhaust tube and put the tank on its rack with the filling holes down and all valves open.

If you have to use the tank right away, you can make it bone dry by putting in two quarts of ALCOHOL, sloshing it around, and then blowing air through the tank. Then repeat the process with ACETONE instead of alcohol.

For laying smokescreens from a higher altitude, the

Navy uses two special SMOKE BOMBS—the 100 pound Mk 3 and the 50 pound Mk 1 Mod. 1. The two bombs are almost identical except for size.

The body of each bomb consists of a hollow WOODEN FLOAT. An aluminum nose casting contains the SMOKE CHARGE (HC) and a built-in FUZE with an 18-seconds delay. Four fins are attached to the bomb to improve its flight characteristics. When the bomb is dropped, the fuze functions on impact with the water. During the 18-second delay of the fuze, the bomb goes down into the water, rises to the surface, and floats. The fuze then ignites the smoke mixture, which produces a dense persistent smoke for 3 to 7 minutes.

The two smoke bombs are suspended from the plane in the usual manner, except that NO arming wires are required. The Mk 3 has two suspension lugs on adjustable bands, while the Mk 1 has only a single suspension band.

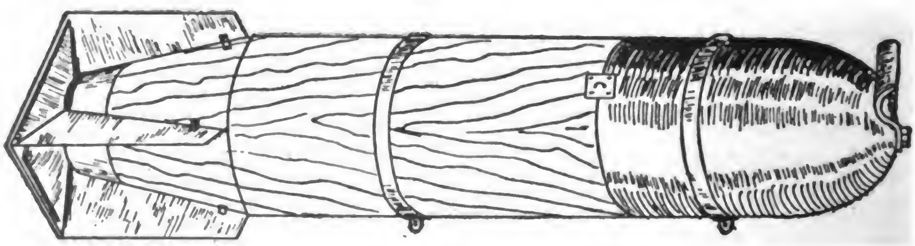
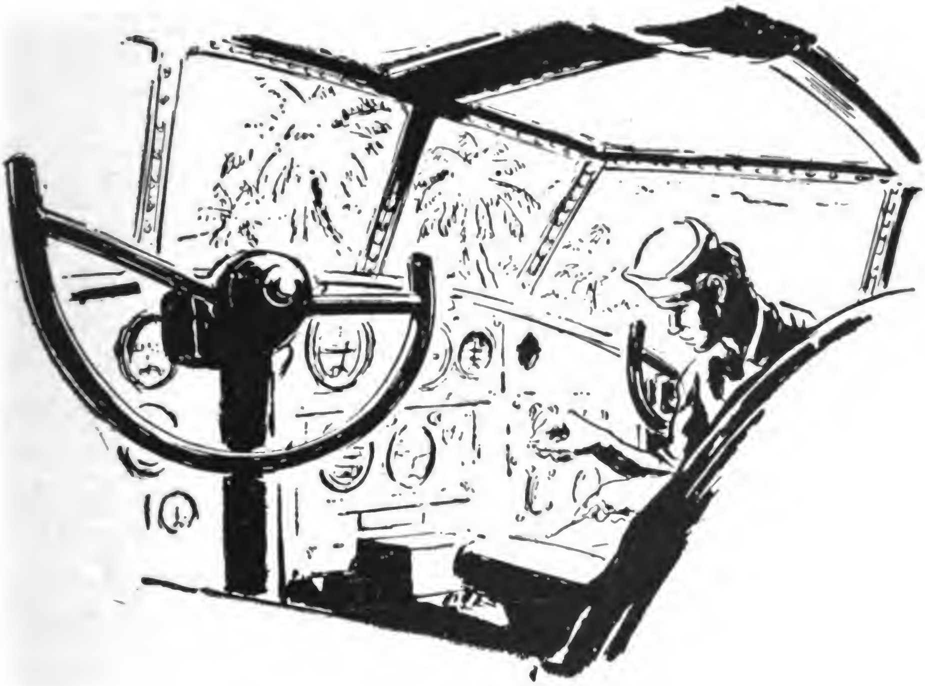


Figure 55.—A 100-pound Mk 3 smoke bomb.



CHAPTER 10

DESTRUCTORS

WHEN FACING CAPTURE

Sometimes it happens!

The airplane is out of control. The port engine is afire. The starboard engine is missing, and she's losing altitude fast over enemy territory. It looks like a long stay in a Jap prison camp for the crew—if they get down alive.

One last job. There's SECRET EQUIPMENT aboard—hot, new stuff that the enemy would give his right arm for a look at. It must not be captured. The bomber presses a switch. There's a sharp report. Two more switches, two more explosions, and the elaborate equipment is nothing but a meaningless jumble of shattered glass, aluminum and plastic.

The DESTRUCTORS have done their work.

A destructor is simply a small EXPLOSIVE CHARGE

encased in a tube which can be screwed or snapped into an opening provided in the secret equipment. It contains a detonator which will explode the charge when a current of electricity is passed through it. Equipment which is to be protected by destructors will have a special FIRING CIRCUIT built into it, with a plug connection which can be plugged into the destructor.

The firing circuit has two SWITCHES in it. One is an ordinary on-off type with a built-in spring which holds it in the OFF position unless it is pushed by hand into the ON position. The other is an IMPACT SWITCH, designed to close if the plane crashes. The two switches are connected in parallel so that the destructor will fire if EITHER switch is closed.

Even though the equipment protected by the destructor may be no concern of ordnancemen, it IS the ordnancemen's responsibility to see that the destructors are INSTALLED and hooked up properly.

Destructors are ordinarily installed in the equipment when it is placed in the plane and are left in place until the equipment requires servicing. It is very important that destructors be REMOVED whenever any servicing or adjusting of the equipment is to be carried out—other than that required for routine operation. If this is not done the destructors may be accidentally detonated, destroying the equipment and perhaps injuring the man who is working on it.

Two types of destructors are in common use. The AN-M1 destructor is a little one. It consists of a small tube 1.3 inches long and about a quarter of an inch in diameter, fastened at one end to a threaded NUT which can be screwed into a receptable in the secret equipment. An opening for an electric plug connection is located in the center of the nut. This destructor, obviously, is too small to do extensive damage. It is designed mostly to break up the equipment enough so that it cannot be used.

When you want to completely destroy a piece of equipment, so that the enemy cannot even figure out how it works, you use the AN-M3 destructor. This is a much bigger affair. The tube is about 6 inches long and nearly an inch in diameter. It has heavy side walls, corrugated so that they will break up into FRAGMENTS, and contains a steel slug or BULLET at the end, which will also throw splinters around. At one end, it has a bayonet type fitting by which it can be fastened to the equipment, and a receptacle for an electric plug. This destructor is big enough to do really substantial damage. It is also big enough to injure YOU seriously if it goes off too close to you.

Destructors are essentially detonators and they should be handled with the same care that is given to other detonators and should be stowed in fuze lockers or similar stowage.

The electrical firing circuit should not be plugged into the destructor until just before the aircraft is to take off. Then, before attaching the plug to the destructor terminal, TEST THE PLUG with a test lamp or voltmeter to make sure that current passes when the firing switch is closed and that no current is present when the switch is open. Be sure that the voltmeter or test lamp you are using is in good condition. The only way to be sure is to test it against another electrical circuit BOTH BEFORE AND AFTER testing the firing circuit. If you don't do this, a burned out lamp might make you think the firing circuit was safe. Then, when you plugged it into the destructor, there would be an explosion.

When it becomes necessary to detonate the AN-M3 destructor, remember that it can be dangerous to anyone in the neighborhood. Ordinarily, fragments won't break through the outer case of the equipment. But don't take chances. See that everyone is clear before you close the firing switch.

How Well Do You Know

AIRCRAFT MUNITIONS?

QUIZ

CHAPTER I

EXPLOSIVES AND HOW THEY WORK

1. What are the three basic characteristics of an explosion?
2. (*a*) If the chemical composition of all explosives is unstable, why do we say that a military explosive should be stable in storage?
   (*b*) What are the other characteristics of a good military explosive? Which of them is directly related to speed of chemical change? How is it measured?
3. (*a*) What is "detonation"?
   (*b*) What is an easy way to start it? What name is given to a substance used for this purpose?
4. (*a*) What is the basic difference between low and high explosives?
   (*b*) Which one may detonate "low order"? What does that mean?
5. (*a*) How can the rate of burning of a low explosive be controlled? How about high explosives?
   (*b*) Where are low explosives used? High explosives?
6. Name and describe the uses of two low explosives and of at least two high explosives.
7. Why is granulated TNT better than cast TNT for booster charges?
8. Why do amatol-loaded bombs have TNT surrounds?
9. How does Explosive D compare with TNT in sensitivity, and how does this affect the use of "D"?
10. What explosive described in this chapter is more powerful than TNT?
11. Where are these explosives used?
    (*a*) Mercury fulminate.
    (*b*) Tetryl.

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CHAPTER 2

GUN AMMUNITION

1. (*a*) If a gun is loaded in two operations with separate loading ammunition, how does that differ from loading semi-fixed ammunition?
   (*b*) How many operations are required to load fixed ammunition?
2. What information is stamped on the case of small arm cartridges?
3. (*a*) What is the function of the primer?
   (*b*) What explosive is usually used in it?
4. What explosive is used for the propelling charge?
5. (*a*) What are the four principal types of bullets?
   (*b*) Which is used against personnel? For setting fire to targets?
6. (*a*) If two bullets have the same lot number, what does it mean?
   (*b*) What does it mean if they have the same grade number?
7. (*a*) Are grade and lot numbers marked on ammunition packing boxes? Why?
   (*b*) Are they marked on the ammunition itself?
8. (*a*) Match the grade symbols at the left with their meanings at the right:

MG	All machine guns.
3	Target practice only (Pistols and submachine guns).
R	Unserviceable.
AC	All machine guns except aircraft machine guns.
2	Pistols, revolvers, and submachine guns.
1	Use first (Priority).
*	Ground machine guns only.

   (*b*) Which symbols apply to caliber .45 ammunition?
   (*c*) Which apply only to caliber .30?

9. How is caliber indicated in the markings on ammunition boxes?
10. What color identifies each of the following types of bullets on the ammunition box? On the bullet tip?
    (*a*) Armor piercing.
    (*b*) Tracer.
    (*c*) Ball.
    (*d*) Incendiary.
11. What are the rules for storing small arms ammunition? What sort of things must it be protected against?
12. Under what circumstances should cartridges be greased?
13. What are the three types of 20 mm projectiles?
14. When should you disassemble a fuze?

CHAPTER 3

BOMBS

1. Where is each of these items located on a bomb, and what is its function?
    (*a*) Fuze.
    (*b*) Adapter booster.
    (*c*) Auxiliary booster.
    (*d*) Fuze seat liner.
    (*e*) Arming wires.
    (*f*) Fin locked nut.
    (*g*) Base plug.
    (*h*) Tail assembly.
2. (*a*) Explain the difference between blast and fragmentation effects.
    (*b*) What does the loading factor have to do with blast and fragmentation?
    (*c*) How will a 1,000 pound bomb having a 30 per cent loading factor compare with a 1,000 pound bomb having a 70 per cent loading factor, as to blast and fragmentation effects?

3. There are three types of bombs described in this chapter having loading factors of less than 50 per cent. For each of these bombs, give the loading factor, type of explosive filling, weight range available, type of target, and type of damage.
4. There are three types of bombs described in this chapter having loading factors of 50 per cent or more. For each of these bombs, give the same information required in question 3.
5. What four types of bombs described in this chapter are not covered by questions 3 and 4?
6. Why do some frag bombs have parachutes?
7. Why do some depth bombs have flat noses?
8. What is the function of a hydrostatic fuze?
9. What is a spotting charge?
10. (*a*) What devices are used to hook bombs to the racks or shackles of an airplane?
    (*b*) What devices are used to fasten lifting cables to bombs?
    (*c*) What attachments are provided on bombs for displacement gear to butt against?

CHAPTER 4

BOMB FUZES

1. (*a*) Name the six parts of a simple explosive train in the order in which they function.
   (*b*) What is meant by a "broken" explosive train?
2. Mention two ways of safetying a fuze.
3. (*a*) What is meant by "arming" a fuze?
   (*b*) What is an arming vane and what part does it play in arming a fuze?
4. Why do many fuzes have reduction gear systems?
5. Which can be made to fire quicker: a nose fuze or tail fuze? Why?

6. (*a*) If the arming wire to the nose fuze is allowed to drop with the bomb, and the wire to the tail fuze is not, what kind of arming is that?
   (*b*) What would be the advantage of that kind of arming?
7. (*a*) What is meant by the "functioning time" of a fuze?
   (*b*) What is the fastest functioning time you will find in a tail fuze?
8. (*a*) How does an explosive train incorporating a delay differ from one which does not?
   (*b*) What are the functions of the additional elements?
9. Is it possible to change the functioning time of an AN-M 100A-2 fuze? An AN-M 103 fuze?
10. What fuzes would you use in a standardized GP bomb weighing 2,000 pounds?
11. (*a*) Where are the Mk 221 and Mk 223 fuzes used?
    (*b*) What is the functioning time of each?
12. How is water pressure used to detonate a hydrostatic fuze?
13. (*a*) What is used to prevent arming of the fuze on standardized Army fuzes during shipment and storage?
    (*b*) What should you do if this fastening is not intact when you unpack the fuze?
14. (*a*) How does the installation of arming wires differ on Army and Navy fuzes?
    (*b*) What special precautions must be taken in installing an arming wire on a Navy fuze which is to be suspended outside the plane?
15. Do all fuzes come with arming vanes separate, or attached?
16. (*a*) Which fuzes are tightened hand tight?
    (*b*) How are others tightened?
17. What maintenance operations are required on standardized Army fuzes?
18. (*a*) What is the fundamental rule for storage of bombs and fuzes?
    (*b*) What are some of the precautions you should take in storing bombs?

CHAPTER 5

TORPEDOES

1. Describe these parts of a torpedo briefly—
   (*a*) Warhead.
   (*b*) Exploder.
   (*c*) Impeller.
2. What is an exercise head and when is it used?
3. At what stage in the operation of the torpedo does it become armed?
4. (*a*) Which valve is responsible for maintaining correct working pressure within the torpedo?
   (*b*) What valves are placed in the air line from the air flask to the valve described in (*a*) above? When does each of these valves open?
5. (*a*) When does the torpedo run without using the alcohol? What is this kind of run called?
   (*b*) How does the use of the alcohol improve the operation of the torpedo?
6. (*a*) What devices are used in a torpedo to keep it at the correct depth?
   (*b*) Explain why there are two of them.
   (*c*) How is the pendulum set to the depth desired?
7. (*a*) What is the purpose of the transportation screw?
   (*b*) What must you remember about it?
8. (*a*) What is the function of the gyroscope in a torpedo?
   (*b*) What is meant by unlocking the gyroscope?
   (*c*) When is this done?
9. What is the purpose of each of these parts?
   (*a*) Starting lever.
   (*b*) Toggle.
   (*c*) Starting lanyard.
   (*d*) Igniter.
10. Name the three main sections of the torpedo and the main parts contained in each section.
11. (*a*) How are torpedoes usually suspended?
    (*b*) What is the purpose of the stop bolt?

12. (*a*) Why is a stabilizer used on the Mk 13 torpedo?
    (*b*) How does the stabilizer affect the water path of the torpedo?
13. To recover a practice torpedo, how should you approach it?

CHAPTER 6

ROCKETS AND ROCKET LAUNCHERS

1. What are the major parts of an aircraft rocket?
2. How is the rocket suspended in the airplane?
3. What part of a rocket keeps it traveling straight through the air?
4. What is the most important precaution you must observe in the handling of rockets?
5. What should you watch out for when removing the nose plug of an HE rocket?
6. (*a*) Describe a rocket launcher briefly.
   (*b*) What is the purpose of the shear wire in a launcher?
7. Explain how to load a rocket into a launcher.

CHAPTER 7

MINES

1. (*a*) What kind of mine explodes when a ship bumps into it?
   (*b*) What kind will explode if a ship just passes near it?
   (*c*) How else can mines be fired?
   (*d*) Which of these types is (are) laid from aircraft?
2. (*a*) What instrument is used to operate a magnetic mine?
   (*b*) What instrument operates an acoustic mine?
   (*c*) What other type of mine is operated directly or indirectly by magnetism? How?
3. (*a*) What is the purpose of the clock starter in a mine?
   (*b*) What force operates it?

(*c*) What would happen if this force were applied to a mine while it was still suspended in the airplane? Why?

(*d*) What is the extender?

4. Why do some mines have a fuze recess in the nose?
5. (*a*) What is the purpose of the static line on the AN-MK 26 Mod. 1 mine?

   (*b*) What happens to the parachute when the mine hits the water?

CHAPTER 8

PYROTECHNICS

1. Why do pyrotechnics require even more careful handling than high explosives?
2. (*a*) What is the difference between a flare and a flash bomb?

   (b) Which one uses a parachute?
3. (*a*) What is the function of the rip cord on a flare?

   (*b*) What is the preferred way of dropping a flare?
4. What are the two major types of flares?
5. How do you adjust a flare so that it will ignite at a certain altitude?
6. (*a*) What are depth charge markers used for?

   (*b*) What are night drift signals used for?
7. (*a*) What are signal cartridges used for?

   (*b*) How are they fired?

CHAPTER 9

SMOKE

1. Explain the difference in the uses to which smoke tanks and smoke bombs are put.
2. What is the smoke-producing agent used in tanks?

3. How do Army smoke tanks differ from Navy tanks?
4. (*a*) What special precautions should you take to protect yourself against smoke mixture, when loading smoke tanks?
   (*b*) What should you do if smoke mixture is spilled on you?
5. Explain how a smoke bomb operates.

CHAPTER 10

DESTRUCTORS

1. What is a destructor?
2. How is it fired?
3. Should destructors be removed from the plane every time a mission is completed?
4. What tests should be made when installing destructors?

ANSWERS TO QUIZ

CHAPTER I

EXPLOSIVES AND HOW THEY WORK

1. Formation of gases, presence of heat, rapid action.
2. (*a*) A military explosive should be stable in the sense that its original (unstable) chemical composition should not *change* as it gets older.
   (*b*) Sensitivity and power. Power. By rate of detonation.
3. (*a*) Sudden, almost instantaneous, conversion into gas.
   (*b*) By another explosion. Detonator.
4. (*a*) Low explosives burn from the surface inward whereas high explosives detonate throughout their whole mass almost instantaneously.
   (*b*) High explosive. A high explosive going off with a weak explosion.
5. (*a*) By controlling the size of the confining space and the amount of explosive surface exposed. The rate of detonation of high explosives involves a basic property of the explosive itself, and cannot be controlled.
   (*b*) Low explosives are used primarily to do work (propellants) and high explosives are used primarily to do damage (burster charges).
6. See pages 13-18.
7. Cast TNT is difficult to detonate.
8. To seal the amatol, which is hygroscopic, against moisture.
9. It is less sensitive than TNT, and is thus better adapted for use as a burster charge in armor-piercing projectiles and bombs.
10. Torpex.
11. (*a*) Percussion caps of small arms ammunition, and primers and detonators in certain bomb fuzes.
    (*b*) Booster charge for high explosives.

CHAPTER 2

GUN AMMUNITION

1. (*a*) The primer, propelling charge and projectile of the separate loading ammunition will be separate; whereas the primer and the propelling charge of the semi-fixed ammunition will be combined in a cartridge case.
   (*b*) One.
2. Manufacturer's initials and year of manufacture.
3. (*a*) To ignite the main charge.
   (*b*) Fulminate of mercury.
4. Smokeless powder.
5. (*a*) Ball, tracer, armor-piercing, and incendiary.
   (*b*) Ball. Incendiary.
6. (*a*) They were manufactured in the same batch, or under uniform conditions.
   (*b*) They may be used in the same type(s) of weapons.
7. (*a*) Lot numbers are marked but grade numbers are not marked, because they may be changed.
   (*b*) No.
8. (*a*)

MG	Ground machine guns only .
3	Unserviceable.
R	All machine guns except aircraft machine guns.
AC	All machine guns.
2	Target practice only (Pistols and submachine guns).
1	Pistols, revolvers and submachine guns.
*	Use first (Priority).

   (*b*) Grades 1, 2, 3 and *.
   (*c*) R.
9. By the width of the colored bands.

	BOX	BULLET
10. (*a*)	Blue on yellow	Black
(*b*)	Green on yellow	Red
(*c*)	Red	No color marking
(*d*)	Red on yellow	Light blue

11. See pages 42 and 43.
12. They should never be greased.
13. High explosive, incendiary, armor piercing, and practice.
14. Only when specific instructions to do so have been received from BuOrd.

CHAPTER 3

BOMBS

1. (*a*) Screwed into fuze pockets fore and aft and bomb body. Explode the bomb.
   (*b*) Screwed into hole in center of base plug. Tail fuze screws into this part.
   (*c*) Inside bomb. Help fuze set off the main charge.
   (*d*) Replaces adapter booster in some bombs.
   (*e*) Run along top of bomb body. Safety fuzes until bomb is released.
   (*f*) Screwed to rear of bomb. Secure tail assembly to bomb.
   (*g*) Screwed in opening at rear of bomb. Close the opening through which bomb is filled with explosive.
   (*h*) Aft. Keep bomb aimed nose down during descent.
2. (*a*) Blast effect is caused by high and low pressure waves traveling out through the air in all directions from the explosion, alternately pushing and pulling at the target. Fragmentation effect involves fragments of the bomb casing itself, splintering and flying outward to pierce the target.
   (*b*) Whether a bomb exerts more blast or more fragmentation effect depends upon the ratio of the weight of explosive to the total weight of the bomb. This ratio is called the loading factor.
   (*c*) It will have more fragmentation effect and less blast effect than the bomb with the 70 per cent loading factor.

3.

	Loading Factor	Type of Filling	Range	Target	Damage
AP	14%	Explosive "D"	1,000 & 1,600 lbs.	Heavy armor	Fragmentation
Frag.	10-15%	TNT	4-260 lbs.	Personnel	Fragmentation
SAP	30%	TNT or Amatol	500 & 1,000 lbs.	Light armor	Fragmentation

4.

	Loading Factor	Type of Filling	Wenght Range	Target	Damage
GP	50%	TNT or Amatol	100-2,000 lbs.	Un-armored	Blast
Depth	70%	TNT or Torpex	325 (or 350) lbs. & 650 (or 700) lbs.	Subs	Blast
Block busters	75%	TNT or Amatol	4,000-16,000 lbs.	Unfortified buildings	Blast

5. Chemical, scatter incendiary, intensive incendiary, and practice.
6. To slow down their descent so that they may be dropped from low altitudes without danger that they will hit and explode before the airplane can get away.
7. To reduce bouncing when the bomb hits the water surface.
8. To detonate the bomb at a certain water depth.
9. A charge (black powder) arranged to go off when the bomb hits, to indicate whether or not it hit the target.
10. (*a*) Suspension lugs.
    (*b*) Hoisting lugs.
    (*c*) Trunnions.

CHAPTER 4

BOMB FUZES

1. (*a*) Firing pin, primer, detonator, booster, auxiliary booster, main charge.
   (*b*) A train having one or more of its elements out of line with the other elements.
2. Prevent the firing pin from moving.
   Break the explosive train.

3. (*a*) Unsafetying it so that it will be free to fire when the bomb hits.
   (*b*) It is a little propeller, attached to the fuze, whose rotation as the bomb falls operates the mechanism which arms the fuze.
4. To prevent the arming vanes from arming the fuze too fast.
5. Nose fuze. The nose fuze can be made to fire before the bomb body actually hits the ground by the pressure of the ground on the firing pin extending out of the bomb nose.
6. (*a*) Selective arming.
   (b) It would allow the bomb to penetrate into the target before exploding, even if the nose fuze were set for instantaneous.
7. (*a*) The amount of delay in the firing of a fuze after the bomb hits.
   (*b*) Non-delay.
8. (*a*) An explosive train incorporating a delay includes a delay element and a second primer (relay).
   (*b*) The delay element interrupts the sequence of the explosive train action while it burns. The relay continues the explosive train sequence by setting off the detonator.
9. Yes. Both have adjustable delays.
10. AN-M 103 nose fuze and AN-M 102 A2 tail fuze.
11. (*a*) Navy GP bombs (over 100 pounds).
    (*b*) 0.01 second.
12. Water pressure moves a piston until it trips a cocked spring-loaded firing pin which strikes the primer and detonates the bomb.
13. (*a*) A loop of wire fastened by a car seal.
    (*b*) Turn the fuze over to an officer for inspection.
14. (*a*) See pages 85 and 86.
    (*b*) A short length of copper tubing must be slipped over the arming wire between the arms of the bracket, as an arming wire guard.

15. Neither. Most fuzes come with the vanes separate, but Navy nose fuzes come with vanes attached.
16. (*a*) Army standardized fuzes.
    (*b*) Spanner wrench.
17. No maintenance.
18. (*a*) With few exceptions, they must be stored in separate magazines.
    (*b*) Protect them from heat and direct sunlight (store under roof or tarpaulin).
    Protect them from rough handling.
    Protect them from moisture and dirt (do not store them on bare ground—use dunnage).
    Store them in properly designated magazine area, the prescribed distance from other structures.
    Except in the Ready Magazine, store fuzes in separate fuze lockers well separated from other explosive material.
    Guard Ready Magazine against unauthorized people.

CHAPTER 5

TORPEDOES

1. (*a*) Detachable nose section carrying the explosive charge.
   (*b*) Mechanism for setting off warhead charge. Similar to bomb fuze.
   (*c*) Wheel which arms exploder by rotation. Similar to arming vanes on bomb except that it is turned by water travel.
2. A head, containing no explosive, substituted for the warhead in practice shots.
3. After it has travelled a certain distance through the water.
4. (*a*) Reducing valve.
   (*b*) Stop valve (opened just before the torpedo is hung in the airplane). Starting valve (opens automatically when the torpedo is dropped).

5. (*a*) While it falls through the air. Cold run.
   (*b*) The alcohol flame expands the air so that it lasts longer and can drive the torpedo faster and further.
6. (*a*) Pendulum and hydrostatic diaphragm.
   (*b*) To prevent torpedo "hunting." (See page 115).
   (*c*) It is not set to any desired depth; it controls level run only.
7. (*a*) To lock the depth-control mechanism so that it will not joggle around.
   (*b*) It must be removed before the torpedo is slung in the airplane, and be replaced by the replacement screw.
8. (*a*) To keep the torpedo headed in a straight line.
   (*b*) Releasing the fastening which keeps it lined up with the axis of the torpedo.
   (*c*) Immediately after the torpedo is dropped.
9. (*a*) Open the starting valve.
   (*b*) Trip the starting lever.
   (*c*) Pull the toggle away from the torpedo when the torpedo is dropped.
   (*d*) Set the alcohol afire.
10. Forward section—explosive charge, exploder.
    Air flask section—air flask.
    Afterbody—nearly all the working parts.
11. (*a*) Between two racks, on suspension cables running between the racks around the torpedo.
    (*b*) To prevent fore-and-aft slipping of the torpedo in its cables.
12. (*a*) To make the torpedo fall in a smooth curve and enter the water nose first.
    (*b*) It does not; it breaks up when the torpedo hits the water.
13. Approach from the lee side, pointing the boat's bow at the head end of the torpedo.

CHAPTER 6

ROCKETS AND ROCKET LAUNCHERS

1. Motor, rocket body, stabilizing fin.
2. By suspension lugs.
3. Stabilizing fin.
4. Never store rocket motors with the bodies assembled to them.
5. The auxiliary booster fitted loosely into the nose fuze seat liner.
6. (*a*) An aluminum sheet rail (box-like beam) with a slot for the rocket's suspension lugs, and an arming control mechanism at the side.
   (*b*) Hold the trigger arm in place until the rocket motor has built up enough pressure to break the wire.
7. See page 138.

CHAPTER 7

MINES

1. (*a*) Contact.
   (*b*) Influence.
   (*c*) By electric lines running ashore. (Controlled).
   (*d*) Influence. (Ground influence).
2. (*a*) Compass needle.
   (*b*) Microphone.
   (*c*) Induction mine. Lines of magnetic force around a passing ship cut the wires in the mine's wire coil, and produce in the coil an electric current which operates the relay switch to explode the mine.
3. (*a*) Prevent the mine from running while it is above water.
   (*b*) Water pressure.
   (*c*) Nothing should happen. Arming wires are threaded through the clock starter and the extender to pre-

vent them from operating even in the presence of hydrostatic pressure.

(*d*) A hydrostatic mechanism which moves the electric primer-detonator against the booster.

4. So that the mines can be adapted for use as bombs, in an emergency, by screwing an ordinary bomb nose fuze into the recess.
5. (*a*) Rip open the parachute when the mine is dropped.
   (*b*) The parachute is released from the bomb.

CHAPTER 8

PYROTECHNICS

1. They are easier to ignite, more easily damaged by rough handling.
2. (*a*) Flares burn, and throw light for several minutes; while flash bombs explode, and throw light for only a fraction of a second.
   (*b*) Flare.
3. (*a*) Start the operation of the flare when the cord is pulled.
   (*b*) Suspend it from a bomb rack like a bomb and release it in the usual manner.
4. High-altitude and low-altitude flares.
5. Set the fuze pointer against the desired drop (number of feet the flare should fall before igniting). Tighten set screw so that the pointer penetrates the flare case.
6. (*a*) To mark a location on water.
   (*b*) Same as depth charge markers, but these are designed for aircraft use.
7. (*a*) Aircraft identification and distress signals.
   (*b*) From a pyrotechnic pistol or hand projector.

CHAPTER 9

SMOKE

1. Smoke bombs are used from high altitudes: they rise to the surface of the water and float there; smoke tanks are used at lower altitudes: their smoke sinks to the water and rises to twice the height of the airplane.
2. FS mixture.
3. Army tanks are cheaper, discharge by gravity rather than gas pressure, and their outlets and inlets are closed by glass plates rather than valves. They are jettisoned after use.
4. (*a*) Wear rubber gloves, acid-proof clothing or apron, and gas mask.
   (*b*) Wipe it off with a piece of dry cloth, and flush the spot with plenty of water and then with a weak solution of baking soda in water.
5. See page 164.

CHAPTER 10

DESTRUCTORS

1. An explosive charge cached in secret equipment.
2. Either by a hand switch or an impact switch which closes when the plane crashes.
3. No. They are ordinarily left in the plane until the equipment requires servicing.
4. Test the firing circuit plug with a test lamp or voltmeter to make sure that current passes when the firing switch is closed but not when the switch is open. Test the test lamp or voltmeter against another electric circuit before and after testing the firing circuit.